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Yu You

Situation Awareness on the World Wide Web

UNIVERSITY OF JYVÄSKYLÄ

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ABSTRACT

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The World Wide Web (web) has become a major vehicle for people to engage in virtual cooperative interaction for their mutual benefits. Although computer-supported cooperative work (CSCW) has been a research topic for decades and even the software industry has adopted corresponding concepts, convincing web solutions are still under development. This is due to a variety of reasons, ranging from social and organizational problems to purely technical issues. In particular, many systems make it difficult or even impossible for people to keep aware of one another. Situation awareness, which is the topic of this dissertation, is treated as a fundamental and key factor in CSCW systems, as it allows people to coordinate and structure their own work such that they can perceive easily what others are working on. This dissertation argues that the neglecting of other users is obstructive, particularly in web-based CSCW systems, where users interact with the system at the same time, but are isolated from each other. It examines the provision of an appropriate functionality that will support situation awareness. In comparison to other traditional awareness research, this dissertation studies awareness from two perspectives: human factors and technologies. Hence, the research objectives are: 1) to study awareness attributes and possible representations of these attributes, and 2) to study different system mechanisms that will largely satisfy the different awareness requirements. The dissertation studies the existing theories of situation awareness and its relevant implementations by investigating the evolution of awareness research, analyzing the achievements made by others, and creating a general framework linking both social and technical perspectives. In particular, this dissertation demonstrates how the theory of situation awareness can be applied to the real environment, i.e. the web, via the implementation of a commercial product.

Keywords: CSCW, HCI, WWW, Situation Awareness, Design Framework

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This work is dedicated to all of you, and my little son, Jieming.

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PART I: INTRODUCTION AND BACKGROUND

1 INTRODUCTION

In this chapter, the context of the research reported in this dissertation is described and the motivation that led to the research is addressed. The selection of research method is discussed following the statements of the research objectives and general research problems in this chapter. Finally, the structure of this dissertation is given with brief descriptions of each chapter.

1.1 Context of this Dissertation

In this dissertation we study scientific issues concerning computer-supported cooperative work (CSCW), and Internet-based information systems. Specifically, the study looks at the concept of awareness and its relevant web implementation. It investigates the evolution of awareness research, analyzes the achievements made by others, and creates a general framework linking both social (human) and technical perspectives. In particular, this dissertation demonstrates how the theory of awareness can be applied to a particular multi-user environment, that is, the World Wide Web (web), via the implementation of a commercial product.

It has been almost seventeen years since the first conference on Computer Supported Cooperative Work (CSCW) held in Austin, USA in 1986. Untill today, the key issues in the CSCW research community are like group awareness, multi-user interfaces, concurrency control, communication and coordination within the group, shared information space and the support of a heterogonous, open environment which integrates existing single-user applications. CSCW is a relatively new field and is a continually evolving subject area that has seen substantial development in the past years as a discipline in its own right. It has been proposed that CSCW research should attempt to encompass all the activities that people can carry out using computers, given to the social nature of work and play (Crow *et al.* 1997). The concerns of CSCW are indeed very broad. However one of the current active research focuses appears to be concerned with awareness issues in virtual communities.

From the perspective of our daily life, awareness is such a natural phenomenon that people rarely notice it, simply because it has existed and been used unconsciously everywhere and at every moment, just like breathing. Awareness, simply said, is a state of mind, or knowledge in general. This implies that awareness is a type of information recognition, or a mental image that reflects the external situation and which is captured by the sensory organs.

> "Awareness of an environment is created and sustained through the perception-action cycle. When a person enters an environment to do a particular task, (s)he brings with them a general understanding of the situation and a basic idea of what to look for. The information that they then picks up from the environment can be interpreted in the light of existing knowledge to help that person determine the current state of the environment, that is, what is happening, and also help them to predict what will happen next. These expectations lead to a further refinement in perceptual sensitivity" (Gutwin and Greenberg, 1999, p. 4).

From the perspective of information system research, however, a good starting point is to understand what a proper interpretation of awareness is and how the concept could be realized in the context of information systems. To allow people to meet and work together, seemingly we need to make them "visible" as a prerequisite. The use of technologies for the purpose of visibility is perhaps the most exciting and primary goal in this context. Awareness is taken for granted in everyday face-to-face environments, such as in our offices. When the settings change to a more open and distributed environment like the Internet, therefore, many of these normal cues and information sources that people use to maintain awareness are missing. A mechanism or system to complement these shortfalls would require the ability to determine and maintain collective awareness information between people in an autonomous or even pre-attentive manner.

The studying field, the Internet, as Jessup *et al.* (1996) noted, is a global network of computer networks that is currently being used to transfer packets of data (text, graphics, audio, and video) back and forth. The underlying technologies support various ways of information search and retrieval from web pages, email/mailing lists, and newsgroups etc. Mark Lottor of Network Wizards (Lottor 2000) estimated that at the time of writing the Internet consisted of countless autonomous networks with 72,398,092 "advertised" connected computers (hosts) in 7 generic and 228 country and territory domains. Because of the unknown and potentially unlimited numbers of multi-user computers and network or application gateways, it is almost impossible to correlate any of information with the real number of end users.

The Internet today has become a widespread information infrastructure, which has resulted in a broad community of users working together to create and evolve the technology. The web built upon the infrastructure provides relatively easy and fast access to an ever-expanding abundance of information sources (text, graphics, audio, video) situated throughout the Internet, each having a unique address and each with the capability of being linked, e.g.

directly or indirectly using hyper links, with any other piece of information anywhere else on the Internet (Jessup *et al.* 1996). Simply by making personal and/or corporate information accessible to the web server, people around the world could distribute and share information with each other. An interesting poll has been carried out about a common question "what else do you like to do on the Internet?" The number one answer of Internet survey is "meet people" (Survey.Net, 2000). The Internet is not only a network of networks based on the TCP/IP protocols and other developing protocols, but also a community of people who use and develop those networks (Krol and Hoffman 1993). And its influence extends "not only to the technical fields of computer communications but throughout society as we move toward the increasing use of online tools to accomplish electronic commerce, information acquisition, and community operations" (Leiner *et al.* 2000).

In this dissertation we are going to thoroughly scrutinize the theory of awareness and related support systems on the Internet, or more specifically, in relation to the use of the web. FIGURE 1 shows the context and focus of the dissertation.

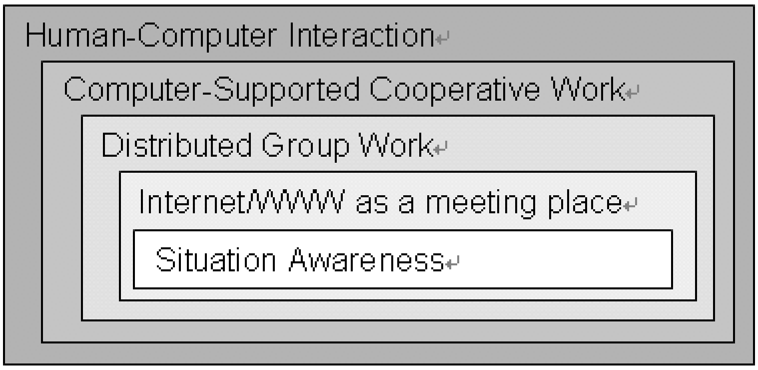

FIGURE 1 Dissertation research context

Based on the work we are conducting, contributions both to the theoretical foundations of awareness support and to its practical implementation are presented in details, concluding with an evaluation of these concepts to illustrate the usability of the results in practice. The major elements of awareness are analyzed in terms of human and system factors, and the relevant technical factors that play the role in the system designing process are also identified. On the basis of the preceding research results, a conceptual framework is developed in this dissertation to categorize and interpret major elements of awareness in the context of CSCW, particularly in favor of the web environment. Along with the framework, the study examines a set of key factors that are essential in building web-based applications, with necessary supports for awareness. Finally, a commercial implementation, the People Awareness Engine (awareness engine), is developed as an experimental instantiation arising out of the present research to demonstrate and evaluate the theories and provides a comparatively new tool for CSCW applications and e-commerce systems.

1.2 Genesis of Research

The term “awareness” or “situation awareness” implies a broader meaning than that intended by most related publications in CSCW literature. In everyday parlance, awareness refers to the up-to-the minute cognizance required to operate or maintain a system (Adams *et al.* 1995). The term has its origin in the commercial and military aviation communities (same time and same place) and has been increasingly finding its way into the literature on human factors and system design (different time and different place).

Usually, or classically people employ a time / place matrix to distinguish various systems between same time (synchronous) and different times (asynchronous), and between same place (face-to-face) and different places (distributed), which was originally developed by Johansen (1988). The research on the subject of awareness has its roots in the same place / same time area (e.g. office systems) and expands gradually over the whole area of the matrix. Especially with the appearance of the global network infrastructure and the de-facto standard web browsing applications such as web browsers, more and more research interest has been shown towards awareness issues based upon distributed systems using the Internet technologies.

> "Electronic mail plays an important role as a successful model of computer-supported communication. Though much CSCW research focuses on providing media which emulate face-to-face meetings, the success of email is a reminder that there is more to good communication support than emulating face-to-face communication" (Reeves 1993, p. 15)

In web-based collaborative tasks, communication between users is not only asynchronous with respect to time and place, but it is also indirect in the sense that the senders and receivers of information may not be known in advance. Grudin (1994a) introduces predictability into the 2x2 matrix of CSCW. Also note that predictability pertains to the participants as well. Web-based cooperation is somewhat unpredictable with regard to the participants who need to communicate. Our focus is on the unpredictable communication that occurs throughout the web sites. Not only are the time and place unpredictable: the participants themselves are not always known over the long life-cycles of complex tasks, for example, the joint-development of Open Source projects.

The role of awareness in the coordination of human activities has been pointed out and discussed in a number of empirical studies of cooperative settings (Simone and Stefania 1997). In the field of CSCW, researchers on distributed cognition who have contributed to groupware research include Hutchins (1990) and Norman (1993); ethnographers who have investigated awareness in work situations include Heath and Luff (1991), Filippi and Theureau (1993) as well as Suchman *et al.* (1991); and groupware practitioners include, for instance, Stefik *et al.* (1987), Tang (1989), and Ellis *et al.* (1991). We shall now present a short historical snapshot on awareness studies in terms of the various research and application fields with respect to the CSCW time-space matrix.

1.2.1 Same Time and Same Place

Awareness can be shown to be important in a variety of the contexts that confront human factor practitioners, such as computer-supported media rooms, and aircraft and air traffic control rooms. In this area, which has the longest history, awareness was recognized as a crucial commodity for co-workers or aircrafts crews. Heath and Luff (1992), studying collaborative activities in a control room, point to occasions of "surreptitious monitoring" and "rendering activities visible" as means for individuals to coordinate their work this way. Bellotti and Rogers (1997) describe how the back-and-forth movement of individuals responsible for different elements of the newspaper front page cues colleagues to the progress of the work.

1.2.2 Same Time and Different Place

If people are not located in the same physical space, a media space can be used to link them together. A media space is a computer-controlled teleconferencing or videoconferencing system in which audio and video communications are used to overcome the barriers of physical separation. Since the early 1980s, many researchers have studied a great number of issues having technical, psychological, and social impact, such as system (network) design, gaze and eye contact, image size, meeting coordination, and privacy and surveillance (Abel 1990; Bly *et al.* 1992; Dourish and Bly 1992; Berlage and Sohlenkamp 1999; Greenberg and Kuzuoka 2000).

Video streaming (constantly) or clips (periodically) can both be used to collect and distribute environmental and users' information, and construct a shared awareness across the different sites and help build a sense of community (Dourish and Bly 1992; Zhao and Stasko 1998).

Under the goal of "tele-presence", collaborative virtual environments (CVE) involve the use of distributed virtual reality technology to support group work. The essence of CVEs is that users are explicitly and virtually represented to each other within a 3-D or 2-D computerized shared space. Furthermore, they should be free to move around within this space, encountering each other as well as objects and information of common interest. The interactive nature of true virtual reality (VR) systems means that they should also be able to interact with each other and with the objects and information. Fahlen *et al.* (1995) in their position paper states that existing groupware systems lack mechanisms providing information about the presence of other users and about their activities and that they do not represent users within applications and environments. They claim that systems' design has to reflect the fact that work is a social phenomenon. It is this social character that makes support for social communication essential. Virtual spaces can be seen as abstract representations of data without any physical correspondence and therefore they can constitute entirely new social arenas for interaction. As an example, the web can be seen as a kind of shared space across which invisible/blind users wander, unable to communicate with one another (Fahlen *et al.* 1995). In order to effectively support collaboration, virtual spaces need to provide awareness support and tools for direct communication.

1.2.3 Different Time and Different Place

Studying awareness in the field of "different time" is particularly interesting. Temporal information is required to enable users to better understand the meaning of the actions of others. In order to incorporate awareness information into purely asynchronous collaboration systems, research is needed with the kind of information visualization that can be effectively provided and exploited in these situations. One approach is to place the awareness information within the shared workspace itself. This approach is used by some synchronous awareness systems, but is especially effective in asynchronous systems for two reasons. First, the shared artifact is, essentially, the only shared space available to the different participants; and second, the key information required in asynchronous collaboration is information about activity of the artifact, not information about activity performed by others (in other words, the artifact is the focus). Chen *et al.* (1996) discussed four dimensions of design considerations for asynchronous awareness maintenance (the awareness of activities) on the web: locus of responsibility, level or size of group, method of locating changes, complexity of user interaction. Chen uses the concepts of cognitive artifacts as means of enhancing human abilities, presented by Norman (1991), to represent changes of information within a shared space (physical or virtual place).

1.2.4 Awareness Model and Questions in General

Dix (1996) defines awareness in a general model (see FIGURE 2) in terms of who is around and their availability for cooperative activity. Group awareness basically comprises information about the actor, the event, the activities, and the reason for the event (Dix 1996). Communication through the artifact, compared to the direct communication, is also a form of awareness.

> "in this case awareness of what has happened. However, there may often be several possible causes of a change and in order to complete the picture we need awareness of how the change happened, which, together with our conversation with other people and understanding of the context, allows us to infer why it happened" (Dix 1996, p. 154).

Awareness can not only benefit information sharing and the coordination of collaborative activities among remote groups, but also drastically reduce the need for explicit communication. Users do not have to explain their activities in great detail if others can receive and understand the information correctly through the environment. Furthermore awareness can help make collaboration more flexible.

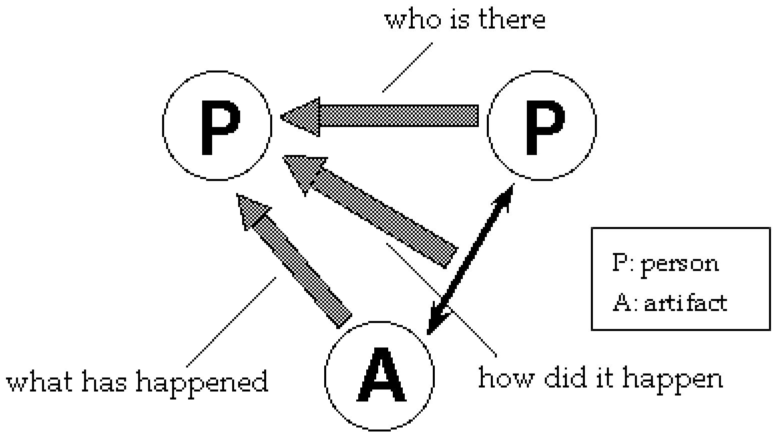

FIGURE 2 Schematic view of group awareness (Dix 1996, p. 154)

Greenberg *et al.* (1996) distinguish between four forms of awareness—informal awareness, group-structural awareness, social awareness and workspace awareness—which in combination form group awareness. For the present discussion, their definitions of informal/user awareness[1] and workspace awareness[2] have most relevance. The two other forms involve knowledge about users' roles and emotional state. To explore the question of what information people need, Gutwin and Greenberg (1997) have constructed a conceptual framework of the elements of workspace awareness. TABLE 1 shows these elements and corresponding questions that users might ask themselves during a shared activity.

TABLE 1 Elements of workspace awareness (Gutwin and Greenberg 1997, p. 2)

Element	Relevant Questions
Presence	Who is in the workspace?
Location	Where are they working?
Activity Level	How active are they in the workspace?
Actions	What are they doing? What are their current activities and tasks?
Intentions	What will they do next? Where will they be?
Changes	What changes are they making, and where?
Objects	What objects are they using?
Extents	What can they see? How far can they reach?
Abilities	What can they do?
Influence	Where can they make changes?
Expectations	What am I to do next?

1 Basic knowledge of who is around in general.
2 Up-to-the minute knowledge a person requires about another group member's interaction with a shared workspace if they are to collaborate effectively.

Many of the elements fall into two rough groups: those that deal with what has happened with another person, and those that deal with how it happened (including questions like who is there). Note that not all elements are present in all situations and the importance of certain elements may vary.

1.3 Research Objectives

Advances in computing technology and widespread networking accessibility have led to a paradigm shift in how people use computers and the applications available for their use. Computers, in a general sense, including PCs, laptops, and mobile terminals, have increasingly facilitated cooperative activities among people, especially those who are geographically dispersed, leading to the development of unique interfaces to allow cooperative works. The glue behind these interactions is awareness, where people track and maintain a general sense of who is around and what others are up to as they work and mingle in the same physical environment. At the meantime, the web has grown very rapidly to become a major resource and information carrier supporting collaborative activities in a wide range of people, disciplines and communities (Chen and Gaines 1996). Simply by making personal and/or corporate information accessible to the web server, people around the world could distribute and share information with each other. The web and its hypermedia structure present a vision of a single huge information system, and then a tremendous opportunity to develop future CSCW research prototypes. However, some barriers to effective collaboration continue to remain. Although the information on the web is shared and public, and web browser provides some kinds of standard operating patterns, the browser remains as a single user tool that separates people from each other, and offer little support for a group of people to contact each other and engage in collaboration over that information (Greenberg 1997). Furthermore, information storage is either centralized (public and shared data) or decentralized (personal or temporary data) over the web. The standard web mechanisms and browsers lack an adequate level of management and control over such data to keep people notified.

The inherent web architecture and underlying technologies supports asynchronous cooperation. Although people can connect to shared databases (web sites) worldwide and exchange information accordingly, which is the basis of human cooperation, many limitations continue to exist; for instance, it is difficult to organize real-time multinational teleconferencing simply because of the different time zones different participants are in. As a result web-based cooperation is mainly asynchronous and chance encounters take place more often than scheduled meetings. Moreover, multiple user support means that the system is able to keep track of tasks and user activities and keep everyone informed. When people on the web interact with each other at the same time (e.g. replying to the same topic in a bulletin board system), they hardly know anything of each other and their activities even they are virtually in the same place (web site/page) and time. This is the major weakness of web-based CSCW systems: lack of clues about user activities. A significant requirement in any groupware system is to maintain awareness, or situation awareness (Norman 1993) by keeping everyone adequately informed. Current web systems isolate users rather than link people together simply because web users are not aware of each other.

The provision of physical community allows people to maintain visibility as to other's locations, activities, and intentions relative to the task. This kind of information provides a shared understanding, or cognition among people, which we term awareness, or situation awareness. Situation awareness is a theoretical concept which derives from cognitive psychology and has mainly been used in aviation research to explain people's awareness of environmental factors and future developments in the environment. The notion of situation awareness offered by cognitive psychology has been criticized, but has since been extended to include system characteristics such as information access, procedures through which to investigate the environment, representational artifacts and communication between different actors.

In psychology, awareness has been formalized to some extent in the models of memory and recall developed with reference to the performance of people in various tasks (Endsley 1995; Watts 1997). This notion of awareness derives from the viewpoint of the individual, so called "self-awareness". In a group-working environment, awareness consists of the states of knowledge of users, the tasks in questions, and the dynamic processes.

In the present research work, two easily confused concepts need to be distinguished: they are awareness and awareness mechanisms. Awareness is the state of mind of users and situational information about tasks and systems, while awareness mechanisms are techniques (or any physical artifacts) employed by users or systems to achieve a desired state of mind and provide situational information. By following this type of definition, we can build up mechanisms or systems that enable such awareness.

Compared to other traditional awareness research this dissertation studies awareness from two perspectives: human factors and technologies. Hence the main research objectives are to investigate:

- *awareness attributes*, and
- *various system mechanisms that can largely satisfy the different awareness requirements.*

Naturally it is most likely impossible to build a universal system that will guarantee the satisfaction or happiness of everyone in terms of awareness. In principle, an awareness system is used to support the relevant collaborative processes. What can be provided, however, is the necessary information to stimulate these processes. In general, the facilities are provided within specialized applications rather than as a set of general or universal independent applicable software packages. The most notable additional need reflected across the existing web-based cooperative systems is that of supporting awareness facilities with respect to the presence and actions of other users.

1.4 Research Problems

One of the key features of CSCW is its inter-disciplinary nature; in particular, the way in which studies and theories from the social sciences can inform the design of computing technology. Much previous work in the design of single-user interfaces has exploited individual's cognitive spatial skills (e.g. the ability to spatially classify and navigate) (Benford *et al.* 1994). The web environment also has a social significance, and how spatial considerations relate to social interaction is thus no less relevant for the design of collaborative systems.

This dissertation does not analyze how information can be best presented in general, or general aspects of building web-based CSCW systems. However, existing work on related issues is analyzed to give answers to questions regarding the design of the different facilities that support awareness on the web. Similar research questions have been asked and investigated regarding a classic task-oriented (work-flow) environment by Sohlenkamp (1999). The awareness study and its prototype in this thesis, however, is designed, built and evaluated to investigate the following research questions:

- Why is awareness important in multi-user environments, especially on the web?
- What are the aspects and possible solutions in the design of a web awareness service?
- How can CSCW systems support awareness on the web? i.e. how can we enrich online opportunities for casual interaction by providing people with a rich sense of awareness of their availability? Or, how can we present awareness information at the periphery, where it becomes part of the background hum of activity that people can then selectively attend to?
- How can we create fluid interfaces where people can seamlessly and quickly act on this awareness and move into conversation and actual work?

1.5 Research Methodologies

There is a plenty of literature on IS research methodologies and although there is no consensus on which research methodology is more appropriate than the others, there is general agreement on the majority of research methods in this field. IS professionals have since acknowledged that political, organizational and social concerns have an impact on the effective use of IS within a company (Backhouse *et al.* 1991). The field of IS, as a result, is a discipline in which practitioners must equally understand both the human and technological factors associated with IS (Avison and Fitzgerald 1991).

Some research methodologies, such as action research, assume that complex social systems cannot be reduced for meaningful study. I believe that human organizations, as a context that interacts with information technologies, can only be understood holistically. In fact action research, as an established research method in the social and medical sciences since the mid-twentieth century, increased in importance for information systems toward the end of the 1990s (Baskerville 1999). The domain of action research is appropriate at the point where a human organization interacts with an existing information system. Since the present research takes too much on new theory founding, system designing and evaluating, the research methodology used in this dissertation focus mainly on constructing the laboratory experiments with respect to the research issues. The test instrument used in this dissertation could be constructed as the supporting and analyzing tool. For this reason the system development (engineering) approach is one of the major research methodologies used in this dissertation.

1.5.1 Research Method

The system development approach has been omitted from most taxonomies or classifications of IS research methods mainly due to the assumption that system development does not lie within the IS research domain. The legitimacy of research and development as a valid research activity within the technical domain of IS has been debated extensively and justified by Nunamaker *et al.* (1991) and Parker *et al.* (1994). IS research has been perceived by some as purely a social science, thus ignoring its technological side. However, this view is changing as more researchers recognize that information systems involve an unavoidable technical component (Parker *et al.* 1994). System development as a research method may bridge the gap between the technological and the social sides of IS research.

In the context of IS research, a proposed theory usually leads to the development of a prototype system with the aim of illustrating the theoretical framework. In some more organization- or society-oriented studies the role of such a system can be played by an existing piece of technology or by the process of technology transfer. Thus, systems development becomes a natural intermediate step linking basic and applied research. In their seminal paper on the role of systems development in IS research, Nunamaker *et al.* (1991) argue that systems development represents a central part of a multi-methodological IS research cycle (see FIGURE 3).

This extended framework of IS research with a systems development component integrated into the research cycle presents a complete, comprehensive and dynamic research process. It allows multiple perspectives and flexible choices of methods to be considered in various stages of the research process.

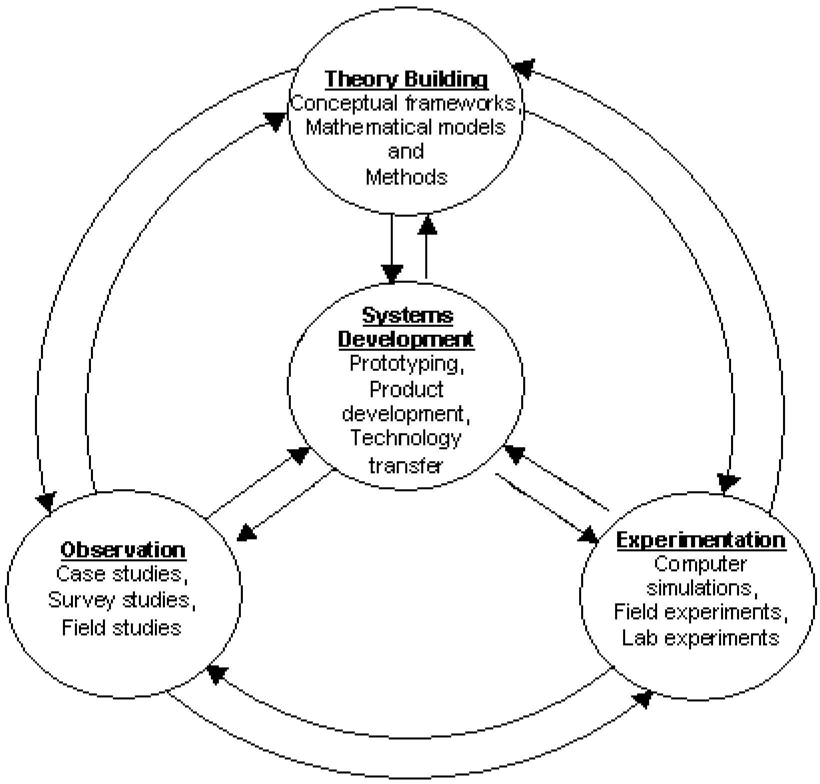

FIGURE 3 A multi-methodological approach to IS research (Nunamaker *et al.* 1991, p. 94)

1.5.2 Research Process

The research process, the heart of any research methodology, is the application of scientific methods to the complex task of discovering answers (solutions) to questions (problems) (Nunamaker *et al.* 1991). The research process outlined in Nunamaker's paper addressed the general elements (or stages) of research. The present research process in terms of these stages can be identified in TABLE 2.

A useful example of a research strategy and framework for building a theory of awareness in collaborative systems is that of Greenberg and Johnson (1997), as illustrated in FIGURE 4. Greenberg's framework describes a cycle of research and development in general. Actually the framework addresses theory-building issues more than it does system development. These phases such as information, translation, display or presentation, and evaluation, rather address social or behavioral issues.

TABLE 2 Research process

<table>
<tr><td>System development research process</td><td>Research issues</td></tr>
<tr><td>1. Construct a conceptual framework</td><td>Identify research questions that have significance for the research field, e.g. situation awareness. For instance, a survey is used to examine the awareness attributes and system mechanisms. The survey data collection is based on a 10-year period, and encompasses the major publications in the Information System (IS) community. The underlying framework used studies awareness in terms of human and system factors.</td></tr>
<tr><td>2. Develop a system architecture</td><td>The general framework is then applied to the specific research field (the web) and lead to research questions in terms of awareness attributes and mechanisms and their underlying technical solutions in order to identify new awareness mechanisms or applications, and to explore some alternatives.</td></tr>
<tr><td>3. Analyze and Design the system</td><td rowspan="2">A commercial product named the People Awareness Engine (awareness engine) is implemented on the basis of theories of awareness studied. The product adds value to all parties by connecting people together and creating web page-based proximity by providing for chance encounters and informal communication as in real life situations.</td></tr>
<tr><td>4. Build the (prototype) system</td></tr>
<tr><td>5. Observe and Evaluate the system</td><td>This phase of the study mainly comprises evaluations of the theories utilized and a usability study of the awareness engine in the context of a real life situation.</td></tr>
</table>

Regarding present research process, specific issues concerning theory construction can be illustrated as follows.

A useful example of a research strategy and framework for building a theory of awareness in collaborative systems is that of Greenberg and Johnson (1997), as illustrated in FIGURE 4. Greenberg's framework describes a cycle of research and development in general. Actually the framework addresses theory-building issues more than it does system development. These phases such as information, translation, display or presentation, and evaluation, rather address social or behavioral issues.

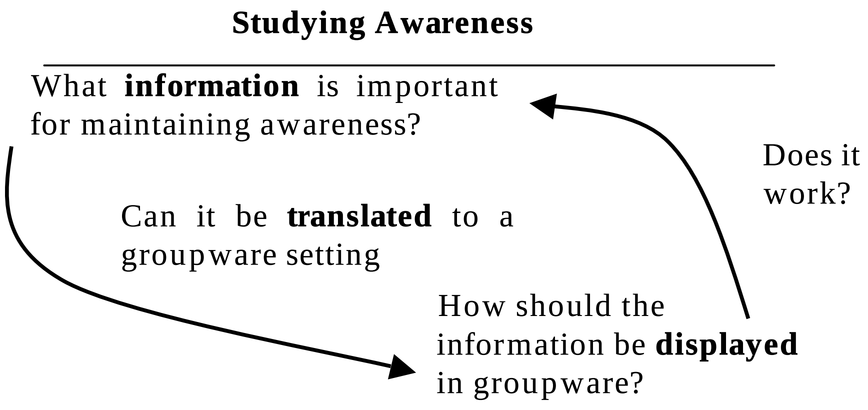

FIGURE 4 Iterative awareness research and development cycle (Greenberg and Johnson 1997, p. 23)

The *information* phase (see FIGURE 4) indicates the need to determine what kind of awareness information people want and/or need. Once the information is identified, the *translation* phase is embarked on. In this phase the information is translated to a groupware setting, if possible. Then the question of displaying the information is addressed. Finally, in the evaluation phase, the outcome of the three previous phases is evaluated. If it does not work, is it because the information, the translation, and/or the display is wrong? Or is the evaluation method not valid? The results of the evaluation lead back to another cycle beginning with the information phase.

1.6 Structure of the Dissertation

This section lists the chapters that make up the body of the dissertation, along with brief descriptions of the problems addressed and the results of each. Materials, ideas, and figures from this dissertation have appeared previously in peer-reviewed publications. The publication details and co-authors, if applicable, are listed for each paper. Basically the advantage of conference/journal publication is that each chapter (3 to 6) is peer reviewed. The inevitable disadvantage is that there is some repetition of the context and background, to make each chapter readable as an individual paper. In particular there are some repetitions; for example, 1) the background knowledge of awareness, which occurs in Chapters 3.2, 4.3.1, 5.2, and 6.2; 2) the description of system development, which is given in Chapters 4.5 and 6.4. It should also be noted that the order is logical rather than chronological. In the two joint papers (Chapter 4 and 6) I am the lead author responsible for the greatest part of both research and writing because the core in each paper concerns my personal research work.

The dissertation is composed of three parts. Part one comprises two chapters. Chapter one is an introduction to the context of the research that was conducted and an explanation of the motivation for the study. Chapter 2 is the literature part and describes the features of a network community and theories of awareness.

Chapter 2 specifies the general awareness requirements for CSCW and groupware concerning group interaction on the Internet. Because of its importance for web-based collaborative systems and for our general prototype, and because of the lack of systematic reviews on awareness issues about the web, an overview of the Internet and its applications from the collaborative community perspective is given.

Part two consists of 4 peer-reviewed published articles (Chapters 3, 4, 5, and 6), which largely discuss situation awareness in terms of the web environment. A brief description of each chapter follows below.

Chapter 3 describes the method chosen to study situation awareness. This chapter presents a review of literature on awareness information in cooperative systems. A conceptual awareness framework is proposed for the specific research area, and includes cognitive and system levels. On the cognitive level three awareness phases and research questions relating to human factors are considered. On the system level five awareness dimensions in different awareness-supporting mechanisms are studied. This level supplies the basis for the representation of awareness information on the cognitive level. To better understand the framework and different awareness factors in different cooperative systems, a retrospective survey of the literature is given on the basis of the relevant publications over the past ten years. This chapter seeks to ascertain the current research focus and provides a general overview for system designing. The development of the field from its emergence in the early 1980s up to the present is described. The original paper was published in the conference proceedings of the Information Systems Research Seminar in Scandinavia (IRIS'23), 2000.

Chapter 4 investigates the web. Technologies provide for the existence of the worldwide infrastructure and for a simple and convenient interface, which is able to support user cooperation. This chapter presents the general concepts relating to situation awareness from the perspective of user interaction on the web, and further develops the framework presented in Chapter 3 by adding an application level based on particular features of the web. The original paper is a joint article with Samuli Pekkola and published in the Journal of Decision Support Systems (DSS), 2001.

Chapter 5 examines the different awareness support mechanisms on the web. In this chapter, the different mechanisms available to support user awareness on the web are presented from three aspects: server techniques, client techniques, and third party applications. The underlying techniques and the pros and cons of each mechanism are analyzed. The original paper was published in the proceedings of the World Conference on the WWW and Internet (WebNet'00).

Chapter 6 presents a complete technical description of the awareness engine (referred to in Chapter 4). The original paper is a joint article with Mike

Robinson and published in the proceedings of the Fifth International Conference for Young Computer Scientists (ICYCS'99).

Part three consists of an examination of the usability and an evaluation of the awareness engine together with a consideration of related issues. Chapter 7 evaluates the study of SA and related implementation. In this chapter the design hypothesis is tested in a usability study and the outcomes discussed. Chapter 8 addresses the major contributions of this dissertation, reviews the research objectives and questions, and concludes with suggestions for future research perspectives.

2 COLLABORATION, AWARENESS, AND THE NET

The technical features of collaboration for CSCW and groupware concerning group interaction on the Internet are presented in this chapter. These features, together with a historical view of the development, are important for understanding and designing group collaborative systems. This chapter divides into two main parts: the first focusing on awareness requirements, and the second on the Internet with its applications. We begin with an overview of CSCW and its applications from the collaborative perspective. Continuing on, we specify requirements from related studies in support of mutual awareness in systems, such as general requirements for diverse awareness information and for the flexible mechanical support of awareness.

2.1 CSCW

Computer-supported cooperative work (CSCW) is a relatively new research field, which has its origins back in 1986 when the first CSCW conference was held in Austin, Texas (Greif 1988). As a discipline, CSCW is located somewhere between technical and human-related issues about which design suggestions are somewhat withdrawn. These design-related issues either provide new guidelines for design itself, or examine whether some previously made assumption is still relevant, useful or even correct. The situation is sharpened by the fact that many papers presented in CSCW conferences or journals show continuous arm-wrestling between technically and socially oriented researchers: the former setting requirements and the latter shooting them down. However, cooperation among these researchers from different origins remains very close and constant.

The term “Computer Supported Cooperative Work” was first used in 1984 to describe the topic of an interdisciplinary workshop organized on how to support people in their work arrangements with computers (Schmidt and Bannon 1992). The exact meaning of individual words or the discipline itself was not defined originally, so many researchers have presented their own conceptions. For example, Bannon and Schmidt (1989, p. 3) proposed "CSCW should be conceived as an endeavor to understand the nature and characteristics of cooperative work with the objective of designing adequate computer-based technologies". On the other hand, Baecker (1993) stated that:

> "Groupware and CSCW systems thus represent a paradigm shift for computer science, one which emphasizes human-human rather than human-machine communications, and problem solving. CSCW systems can integrate voice and video communication with shared digital workspaces and can support work that occurs both synchronously and asynchronously. Thus groupware technology enables both expansion of both the concept of a meeting and that of collaborative work, allowing participants to transcend the requirements of being in the same place and working together at the same time." (Baecker 1993, p. 2.)

These two quotes point to the main difference between groupware and CSCW, since these terms are often confused. Nevertheless, the term groupware, can legitimately be used refer to CSCW as CSCW can be seen as a focus on the design of software that supports group work (i.e. groupware) (Schmidt and Bannon 1992).

> "[Groupware] emphasizes the application of information technology (IT) to support group work in various environments such as manufacturing plants, factories, offices, and distributed virtual offices of large corporations – provides the basis for distinguishing it from the pure study of technology to support group work, which seems to be the general focus of CSCW (Johansen 1988). In this sense, groupware can be seen as a sub-class of CSCW, more preoccupied with the impact of information technology on group work practices in organizations so that improvements in efficiency and effectiveness can be achieved" (Kock, 1997, p. 51)

One traditional method of classifying the various kinds of CSCW systems is by determining the place and time of the collaborative interactions that are supported. This categorization was presented by (Johansen 1988) and has been used since then. Collaboration may occur between people in the same place (physical or remote but visually co-located) or different places (remote) and may also occur at the same time or at a different time (synchronous or asynchronous). Examples from the main four quadrants are:

- Same time and same place: meeting support tools.
- Same time and different place: video conferencing.
- Different time and different place: email, electronic forums.
- Different time and same place: white/blackboards, multi-user workflow systems.

FIGURE 5 illustrates the quadrant, using somewhat refined taxonomy from Grudin (1994a) with nine fields instead of four. It extends Johansen's (1988) interaction-distribution matrix by adding predictability (predictable versus unpredictable) to the place and time of interaction and distribution. Representative applications illustrate the different cells. Grudin came to the conclusion that in asynchronous cooperation one must know whether other users will react within a predictable time-frame or not. Similarly, in remote cooperative situations knowledge of where partners are makes a difference.

<table>
<tr><td colspan="3" rowspan="3"></td><td colspan="3">Time</td></tr>
<tr><td rowspan="2">Same</td><td colspan="2">Different</td></tr>
<tr><td>P</td><td>U</td></tr>
<tr><td rowspan="3">Place</td><td colspan="2">Same</td><td>Meeting facilities</td><td>Work shifts</td><td>Team rooms</td></tr>
<tr><td rowspan="2">Different</td><td>P</td><td>Telephone, video conferencing</td><td>Email</td><td>WWW</td></tr>
<tr><td>U</td><td>Interactive seminars</td><td>E-Forums</td><td>Workflow</td></tr>
</table>

P: Predictable, U: Unpredictable

FIGURE 5 CSCW spatial and temporal quadrant

This typology is easy to learn and facilitates communication. Consequently it is widely used, especially by system developers, but this does not mean it is complete and perfect. For example, FIGURE 5 obscures an organizational perspective that has caused the failure of many cooperative systems (Grudin 1994a).

2.1.1 CSCW Applications

It is necessary to have a historical review on various categories of CSCW applications to gain general comprehension about the important demanding and popular acceptance for CSCW applications. Many of the following categories and analysis are based on Ned Kock’s thesis (1997) but some extra categories are added such as collaborative virtual environments and mobile computing systems, since new technologies came into use. This categorization, however, just provides a very gross taxonomy for CSCW applications. With the development of technologies, the boundaries between applications are becoming vague. Therefore only common characteristics will be discussed in each category.

Electronic-mail: Electronic-mail (email) is often recognized as the most widely accepted and successful groupware used in organizations. It is among the quite few early computer systems to be developed with the aim of supporting communication among people. The success of email may be credited to its high similarity to the common ordinary mail system. However, email is hardly completely affirmed as a groupware because of the lack of interoperability between people. Mailing lists, newsgroups, or bulletin boards, along with email, generally allow people to exchange information related to a given topic. Messages are organized according to the topics, and are sometimes mediated by one or several dedicated persons, e.g. the conveners. However, in a dynamic environment where large amounts of information are created and updated frequently, email or mailing lists are no longer suitable because the underlying mechanism lacks data persistence and consistency.

Video Conferencing: Video conferencing applications are workstation or PC-based point-to-point audio and video systems intended or non-intended for collaborative work, as well as text-chat, whiteboard, or file transfer. The use of video conferencing systems in organizations can be divided into two categories: planned meeting systems and casual meeting systems. Planned meetings often utilize formalized communication channels and purposeful subjects for meetings. Casual meetings, on the other hand, are more spontaneous and mainly for informal communications.

Workflow control: The main function of a workflow control system is to design and keep track of the execution of interrelated activities (Nedina-Mora *et al.* 1992; Grinter 2000). The role of workflow management systems is to define a task into a set of sequential sub-tasks in a suitable work process performed by individuals. When a sub-task is finished, the work continues to the next person who is responsible. This type of task automation often requires a re-engineering process, which eventually brings great impact on the old, existing interactivity model within an organization. The research challenge workflow systems brought out was to find ways to support the work of individuals in a purposeful manner (Grinter 2000), that is, to make systems more flexible to support static tasks, and assist the contingent aspects.

Group calendaring/scheduling: Group calendaring and scheduling applications extended the concept of the personal electronic calendar through the support of multiple users over networked computers. People can not only reserve their time and tasks individually, but also have access to others' time schedules if applicable. This information-sharing capability even enables cross-booking, with one person able to book appointments for another, or to finding whether a prospective meeting suits another's schedule (Lange 1992). Calendaring and scheduling systems are gaining usefulness by integrating email and other management functions. The productivity benefits, however, come only with a critical mass of users in the system, and the risk of failure still exists (Grudin 1988).

Group decision support: Group decision support system (GDSS) is considered the first example of groupware, starting originally from the management information system at University of Arizona. DeSanctis and Gallupe (1987, p. 590) provided the definition of a GDSS as "an interactive computer-based system that facilitates the solution of unstructured problems by a set of decision-makers working together as a group". The main goal of GDSS is to support group decision-making process by enabling anonymous electronic brainstorming, voting, ranking and classification of ideas (Nunamaker 1989). GDSS has high requirements in time, widespread participators, and honesty of use. Many of these issues, however, can hardly be solved through the utilization of information technology.

Collaborative authoring/drawing: This type of application enables two or more authors of a document to synchronously work together, non-visually such as co-authoring tools (Galegher and Kraut 1990) or visually such as ClearBoard system (Ishii and Kobayashi, 1992). Computer-supported collaborative authoring must support two fundamental design features: the ability to identify the commenter and the capability to display multiple items of interest simultaneously. For instance, a person may acquire an "all-together" workspace in the monitor that contains his portion of the text, the guidelines of writing, and a coauthor’s comments. ClearBoard (Ishii and Kobayashi 1992) used a shared virtual whiteboard (tilted three-layer screen) and a digitized pen over the shared workspace to maintain gaze awareness of the other user and support eye contact.

Shared work space: This class of groupware provides shared computational workspaces where people can create and manipulate task artifacts, for example, the group toolkit in Calgary (Gutwin and Greenberg, 1998a; Greenberg and Roseman, 1998). Shared workspace systems are usually real-time, synchronous, and used together with other communication tools to support non-structured interaction among members.

Media space: Normally a media space can be simply understood as a computer conferencing system supporting user collaboration. Media space systems use integrated video, audio, and computers to allow spatially and temporally distributed individuals and groups to work together (Bly *et al.* 1992). Using the media space, not like one-to-one videoconferencing, each person can observe the others’ presence through one common or several video screens or channels located nearby and can have aural conversations with one another. One common use of the media space system is to establish a live screen in a public area like a hallway, to achieve a "glance" effect for individual activities. This configuration provides a type of peripheral awareness for people and their workspaces.

Collaborative virtual environments: Collaborative virtual environments (CVE), such as Massive (Greenhalgh and Benford 1995), and DIVE (Fahlén *et al.* 1993), enable direct interaction among embodied participants (avatars) in virtual worlds (Bowers *et al.* 1996). The virtual environment includes really textually-based systems such as MUDs and MOOs, and 3-D virtual reality (VR) technologies as the user interface. Such systems differ from other groupware systems such as media spaces in a way that people are embodied and visualized instead of real video imaging. People explore the artificial environment independently and navigate (walk or fly) to a common virtual location and work together on some artifacts. Research efforts on CVE have mainly concentrated particularly on application design, the development of underlying architecture and spatial models for virtual worlds, and some empirical studies of these systems (Benford *et al.* 2000).

Mobile computing systems: With the development of wireless technologies, the use of mobile handheld devices, such as PDAs (Personal Digital Assistants) and advanced mobile phones make it possible to set up communications at any time and any place, not relying on dedicated rooms and environments (Schmidt *et al.* 1998). So far, research on mobile computing has mainly concentrated on technical issues.

2.2 Collaboration and Awareness

Collaboration, defined according to Merriam-Webster dictionary, is “to work jointly with others or together especially in an intellectual endeavor” (Merriam-Webster Online, 2002). The joint work requires information shared among people (Ellis *et al.* 1991). The sharing of resources among people therefore can be seen as a central capability of a groupware system. In talking about information sharing, generally we mean two types of sharing: synchronous and asynchronous. Synchronous sharing means that different people access the same resource at the same time. On the contrary, asynchronous sharing means different people access the same resource at different time. Asynchronous sharing, technically, is just a matter of design: a system allowing users to access documents from different physical locations, such as from different workstations, can be seen as supporting asynchronous sharing. Currently more and more systems have the networking capability to allow both types of sharing.

Improvements in the computing performance of computer hardware and increasing connectivity of the global infrastructure led to an increasing number of computer systems supporting multiple users at the same time. Supporting multiple users implies that users of a system can exchange information, collaborate on resources, and even coordinate their tasks. Although these users can interact with each other through common applications at the same time, they know little of each other or of each others' activities. Indeed, present computer systems isolate users, giving them a reduced awareness of each other (Rodden *et al.* 1992). A critical requirement in shared tasks is maintaining situation awareness by keeping everyone adequately informed (Norman 1993).

The design of each computer system is guided by the designers' assumptions about the future use of the system. The underlying model of use is usually one of a strictly single-user activity, which in effect prohibits “on-site” collaboration. In contrast, cooperative applications wish to be aware of the activities of other users and to support and encourage these activities between users' (Rodden *et al.* 1992, p. 42). Studying collaborative systems does not simply mean adding user visualization to applications, but is a totally new subject, a “New World”. As Harrison and Dourish (1996) said, when audio and video are added to a textual interface, the result is clearly not the same system with more bandwidth. Instead, one finds a new kind of medium, with behaviors and uses changed radically. For this reason, situation awareness is a critical area of study.

2.2.1 Situation Awareness

Awareness has been seen and recognized as a phenomenon for a long time, under the name of situation awareness (SA) (Gilson 1995). Studies began in military aviation, where pilots would receive and understand an up-to-date situation and respond appropriately. Situation awareness research generally involves environments that are complex mechanical systems, such as aircraft and power plants.

Situation awareness can be most simply defined as “an appropriate awareness of a situation” (Smith and Hancock, 1995, p. 146). Situation awareness refers to the up to the minute cognizance required to execute and maintain a system. In even an individual task, a person must have enough knowledge and capability to behave properly. Situations become more complex when they involve groups. They require a collective understanding of the tasks and any events coming out during the execution of the task. That is to say, the work requires the understanding of the up-to-the-minute situation and the appropriate reaction. Yet, situation awareness is not identical with performance. For instance, it is entirely possible to have good situation awareness and still make wrong decisions for many reasons. And it is also possible to perform perfect tasks with minimal situation awareness. So situation awareness is not only the ability to attend to the various events, signals, and any information resources in a complex system, but also to determine their relevance and implications in a timely and appropriate manner. Endsley (1995b) defines situation awareness as the “perception of the elements in the environment within a volume of time and space, the comprehension of their meaning, and the projection of their status in the near future” (Endsley, 1995b, p. 36).

In talking about situation awareness, we have to compare it with the definition of another psychological term “consciousness”. We treat situation awareness as an externally directed consciousness that will generate more purposeful behaviors in a specific task environment than general consciousness does. Generally speaking, consciousness is a piece of mental image that would eventually lead to a behavioral reaction towards the external stimulus. However, to study situation awareness in the context of CSCW, consciousness may lead to the automacity of processing. When one lacks the ability to recall the cues that initialized the behavior, the whole reacting process can be made subconsciously, which may not be permitted and even dangerous in some mission-critical cases. So situation awareness, as a state of knowledge, is distinguished from the definition of consciousness, situated outside the human mind, and studied as a mechanism to convey required information. Established doctrine, rules, procedures, and checklists are static knowledge that fall outside the study of situation awareness, because situation awareness refers to only that part of knowledge related to the state of a dynamic environment.

2.2.2 Situation Awareness and CSCW

The research on CSCW has studied various kinds of awareness support systems with which people can keep track of updated information about individuals or groups. All of them can be viewed under the heading of situation awareness in terms of their different application domains. One of the well-known definitions of awareness in the CSCW literature is given by Dourish and Bellotti in their seminal paper on awareness and coordination in shared workspaces (Dourish and Bellotti 1992, p. 107). They define awareness as being “an understanding of the activities of others which provides a context for your own activity".

Therefore, it is particularly important to recognize that the context within which people collaborate comprises information both about users and about tasks. Therefore the definition of awareness is not limited to human factors alone but also includes system factors. Moreover, the state of computer-mediated cooperation may be influenced not only by the human participants, but also by the equipment itself, which may be seen as another actor to hold in awareness. Chen and Gains (1997) argued that one of the important criteria for achieving group cohesiveness is the situational awareness of what other group members are doing. The emphasis on the importance of cognitive artifacts in their paper was rooted from Norman (1991). A cognitive artifact is defined as an artificial device designed to maintain, display, or operate upon information in order to serve a representational function (Norman 1991).

We can identify two categories of situation awareness: user awareness and workspace awareness. The ability to relate ongoing perception to existing knowledge, i.e. to be aware of something, requires both of these awareness aspects. User awareness (or informal awareness) of a work community is the general sense of who is around, what they are up to, and whether they are available. These are the kinds of things that people need to know when they work together in a shared physical place (Kraut *et al.* 1990; Dourish and Bellotti 1992). The concept of “Peripheral awareness” (Heath and Luff 1991) can be treated as a subset of informal awareness, that is the ability to see out of the “corner” of one’s eyes. People maintain and constantly update a sense of their social and physical context in an apparently effortless manner and without being aware that they do so - at least until something happens that is out of the ordinary and causes people to raise their level of consciousness (Pedersen and Sokoler 1997).

User awareness also addresses issues which emerge during conversations, particularly in electronic meeting systems and media spaces. People continually adjust their verbal behavior in conversation, based on cues picked up from their conversational partners. Some of these cues are visual, like facial expressions, eye contact, or gestures; others are verbal, like intonation, or the use of particular words. These cues provide a sense of awareness of what is happening in the conversation, awareness that helps people make adjustments and adaptations to keep things going smoothly.

The capability of user awareness of others’ activities may also be important for systems seemingly targeted at single users as well. One example, presented by Parikh and Lohse (1995) described a system supporting the futures market at the Chicago Mercantile Exchange (CME). While the system offered the capability to trade futures electronically, it overlooked the social dynamics of the real stock exchange. In the trading pit, people are aware of the actions of other traders, which greatly influence their own decisions. “Traders sometimes choose which pit and its respective contract to risk their money in by the noise associated with it” (Parikh and Lohse, 1995, p. 300). Finally they created an electronic pit representation of the trade process on traders’ screens to enable such awareness cues of others’ activities.

Workspace awareness (Greenberg *et al.* 1996; Gutwin and Greenberg 1996; Lee *et al.* 1996; Gutwin and Greenberg, 1998a) can be viewed as a special domain of situation awareness since it is very tied to specific work settings: spatial representation, bounded interpretation, and perceptual availability. For example, the spatial nature of workspaces means that artifacts and events can be interpreted in part by their location in the workspace. Compared to peripheral awareness, workspace awareness is not inconsequential and takes more responsibility for the primary group activity.

Chen and Gains (1997) presented a specific conceptual framework with respect to group and organizational factors of awareness maintenance. The concept of collective awareness was rooted from the theory of collective intelligence theoretical model by Smith (1994). Chen and Gaines discussed two analogous forms of awareness that can be identified for groups: awareness of the group's collective long-term memory (LTM) and awareness of each other. The collective LTM has two parts: the artifact and the body of shared intangible knowledge. Global awareness, deep awareness, and peripheral awareness can each be considered under the category of workspace awareness and be identified as the different intensities of workspace awareness. The definition of awareness of each other is rather obscure and "closer to the notion of situational awareness", as noted by the authors. Resource awareness and chronological awareness are comparatively comprehensible because they address the issues of resource-locating and time questions. However the concept of "task-socio awareness" is fairly difficult to be computerized. The meanings of task-socio awareness is "another form of awareness involves the interaction between social and intellectual processes operating within in the group" (Chen and Gains, 1997, p. 14). One might question: who really is reacting what? Is it necessary to introduce new group interdependency among people? Grudin (1994b, p. 96) has noted that "many organizations are structured and responsibilities are divided in order to minimize the overall communication requirements and social interdependencies". Therefore Grudin suggested that,

> "if possible, add groupware features to an already successful application rather than launch a new application with a fanfare that creates expectations of heavy use. Ultimately, creating awareness of and access to infrequently used features could require systems that take the initiative to educate users over time. Work in this area, mostly in AI, has proceeded slowly. Yet the need grows, as computer capability exceeds by ever greater amounts our actual use of them" (Grudin, 1994b, p. 96)

In general, on the macro level of awareness, knowing what others are doing and whether they are available for communication (user awareness) is important. On the micro level of awareness, knowing who is talking to whom (user awareness) and who is working on what (workspace awareness) are as important as well.

2.2.3 Awareness Support for Collaboration

Gaver (1991) presented a simple model of shared work. The model discussed three forms of increasingly focused cooperation: serendipitous communication, division of labor, and focused collaboration. "Awareness is necessary for all collaborative work, but the degree to which its focus is shared varies" (Gaver 1991, p. 295). Different levels of focused collaboration require awareness correspondingly, but some basic awareness support is required in all levels. Furthermore, awareness is also necessary to facilitate changes among the different phases of work. Awareness can be thought of as a prerequisite for collaboration because “perceiving, recognizing, and understanding the activities of others is a basic requirement for adequate human interaction and communication in general” (Sohlenkamp, 1999, p. 42).

In real-time collaborative environment, Gutwin *et al.* (1996b) studied group interaction by a composing task of a newspaper. They identified several technical problems in the design of groupware, such as the smaller perceivable environment than the real workspace, difficulty of communication, lack of awareness of others’ activity, and obstructive use of groupware. They argued that people are aware of many things when they work in group, some of which relate to the group, and some to the tasks or situation more generally (Gutwin *et al.* 1996b). In that paper, they presented four types of awareness that apply to a close-working group, especially face-to-face situations (see FIGURE 6). Those different kinds of awareness overlap, inform one another, and interact during group work.

Informal awareness: the general sense of who’s around and what they are up to, which mainly facilitates casual interaction. For example, media space (Baecker 1993) is used as an attempt to provide this type of social presence to distributed group members.

Social awareness: the information that a person maintains about others in a social or conversational context. Social awareness can be easily maintained in a face-to-face situation but is difficult to maintain in groupware because the social cues are completely missing or hard to convert into such a meaning level. Video teleconferencing and virtual reality technologies such as collaborative virtual environments are in use.

Group-structural awareness: the knowledge about group members’ roles and responsibilities, their positions, status, and group processes.

Workspace awareness: the knowledge about the others’ interaction within the work space and its relevant artifacts. Workspace awareness differs from the other forms of awareness because it is very domain and task-specific and usually provided individually and explicitly in groupware systems.

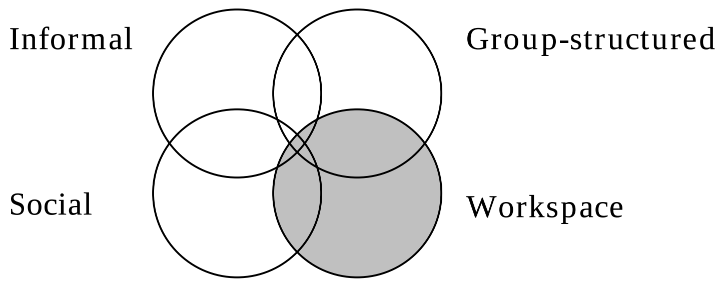

FIGURE 6 Types of awareness in group work (Gutwin *et al.* 1996a, p. 287)

Based on the study by Gutwin *et al.* (1996a), they built a framework (See TABLE 1 in Chapter 1) for workspace awareness according to a number of elements that play a role in this form of awareness. For each element, they considered the mechanisms people use to gather awareness information.

Mark and Prinz (1997) noticed the conventions in the course of group development in a document-central system. They observed the difficulty of setting conventions among users for several possible reasons: 1) "restricted feedback and communication makes it difficult to establish conventions", 2) "the group environment lacks cues for conventions", 3) "individuals may be reluctant to give up their individual conventions", 4) some conventions with groupware are totally new for the group", and 5) "unfamiliarity with the system". Their observations proved once again the development challenges of groupware presented by Grudin (1994). Mark and Prinz suggested four levels of the provision of awareness cues for conventions:

- Visualization: to use appropriate metaphors to visualize conventions;
- Notification and provision of feedback: to support user training and constraint the unintended user behavior;
- Automatic ensurement of conventions: to avoid inappropriate user behavior; and
- Enforcement of conventions: to constraint the user's inappropriate conventions.

Other awareness mechanisms will be discussed further in Section 2.4.

2.2.4 Awareness Support for Coordination

Groupware systems need to allow experienced members to see what others are doing at a glance. This can be supported both explicitly by the systems and implicitly by the nature of the artifacts. A typical example is provided by Heath and Luff (1992) about the working situation in a non-computerized London Underground control room. While the operators worked in a control room and every change of operators' positions and actions may have direct or indirect influence on the others. Operators avoided having their activities so visible and noticeable to the others if the activity or response was independent and individual. However, it had been observed and proved that operators usually monitor and overhear the situation of their colleagues' activities and coordinate their own tasks accordingly without the necessity to engage in explicit communication.

> "It is not simply that …[operators] happen to remain attentive to the local environment of activity and are able to draw the necessary inferences from the actions of their colleagues. Rather, personnel within the Control Room organise their conduct so that whilst engaged in one activity, they simultaneously monitor the conduct of others." (Heath and Luff, 1992, p. 34)

Both explicit and implicit communications among operators were therefore required to be maintained in an efficient way. Peripheral awareness of each other illustrated in their case presents an aspect of skilled work supported by the physical nature of the artifacts used. Another example is provided by Whittaker and Schwarz (1995) about the use of a common whiteboard to facilitate scheduling work. In their study, a large material whiteboard is located in a public area and promotes group interaction around the board. The implication is that the artifact, i.e. the whiteboard, makes the management tool become a valuable personal and group resource. First, the board's ready visual, public availability made it easy to employ for personal and group reminders. Also it provided a place and focus for synchronous and asynchronous group planning. With the awareness support of task scheduling, one interesting finding mentioned in this paper is "belief and commitment arose from the visual, public nature of the board encouraging greater responsibility" (p. 501). Similar studies have been conducted for other domains as well: examples such as air traffic control by Hughes *et al.* (1992), stock exchanges (Heath *et al.* 1993; Parikh and Lohse 1995), civil engineering (Rogers 1993), and health care (Luff 1996). In those cases, "cooperative works are implicitly coordinated by observing the activities of others or through their actions on the common artifacts" (Sohlenkamp 1999, p. 56). Therefore providing awareness information is necessary in electronic (computer) enhanced collaborative systems.

2.2.5 Awareness Support for Communication

One of the core roles of groupware is supporting formal communication among group members. In an environment where each member has a well defined role, the need to have face-to-face communication in order to perform a cooperative task becomes less necessary if mechanisms for situational awareness have been well established between members (Chen and Gains 1997). The way people communicate with each other can be direct versus indirect, local versus remote, and explicit versus implicit. The difference between explicit and implicit communication is crucial: explicit communication consists of all forms of structured communication acts, either verbal speech (face-to-face or mediated by technical means), written documents, or message passing. However, a significant amount of communication is performed implicitly and informally, mediated by a variety of different channels. Examples are unstructured speech acts such as utterances, gestures, or suggestive fragments. Very often, naturally occurring informal contacts and efforts at communication provide an opportunity for collaborators to learn about each other, and serve as a framework within collaborative tasks (Kraut *et al.* 1990). Quite often, implicit communication is mediated indirectly by the work artifacts. In this case, the state of the work objects provides implicit means for communication between the group members (Dourish 1997). These interrelated, implicit cues allow the flexibility that is inherent and essential to most cooperation processes. Basically, it is these cues that form awareness information.

Usually direct communication means the conversation carried out in a group for effective interaction. "Often unconsciously, our actions are guided by social conventions and by our awareness of the personalities and priorities of people around us" (Grudin, 1994b, p.98). Conversation is an essential part of the use of CSCW systems to support efficient work. Another implementation of communication is informal spontaneous communication (Kraut *et al.* 1990). However, this interaction situation does not apply in all respects to contact facilitation or casual interaction, especially asynchronous interaction on the web. The recent explosion of instant messaging services shows support for contact facilitation. A person sees friends and their on-line status in his buddy list, and selectively enters into a chat dialog with one or more of them. The general idea is that members of a distributed community track when others are available, and use that awareness to move into conversation, social interaction and work.

Many researchers are concentrating on designing interfaces that facilitate how people can establish contact with one other. These contact facilitation interfaces typically contain two components (Greenberg and Johnson 1997):

- the provision of information which helps people stay aware of who is around in their community, whether those people are available for conversation, and whether it is socially acceptable to initiate a conversation with them; and
- the ability to actually initiate a communication and/or collaborative session (i.e., a shared application combined with a voice channel).

> “Informal communication means the opportunistic, spontaneous, and unplanned interaction between people (Kraut *et al.* 1990). Whittaker *et al.* (1994) report that informal communication makes up 25% to 70% of face-to-face communication. Informal communication builds and relies on a common context. This shared background is again based on mutual awareness of co-located workers. Without technical support, awareness can only be achieved by proximity” (Sohlenkamp 1999, p. 56)

Examples of systems that support informal communication by showing in some way the availability or otherwise of others are Portholes (Dourish and Bly 1992), Nessie (Prinz 1999), and similar systems (Greenberg 1996; Ljungstrand 1999). The Montage system (Tang and Rua 1994) combines video conferencing with an ability to ‘glance at’ others before opening a video link. They use the term "teleproximity" for their objective using video “to help glances feel as unremarkable as people walking by an open office door” (Tang and Rua 1994, p. 5). In this way a lightweight mechanism is established which provides awareness of others before any attempt at video communication is made.

2.3 Potential Problems of Providing Awareness

So far the advantage and essential nature of awareness support has been discussed. However, even if technical issues have been satisfied in a CSCW system, future problems remain. Generally speaking, there exist two potential pitfalls for supporting awareness in a multi-user collaborative environment, whether physical or electronic. These associated issues are user disruption and privacy violations. While systems can convey significant information to support awareness and informal interaction, many studies (Hudson and Smith 1996, Clement 1994, Greenberg and Kuzuoka 2000) addressed the fundamental privacy and disruption tradeoffs in various awareness support systems. Let us simplify this situation by using a cycle illustrated in FIGURE 7. FIGURE 7 shows work discourse as a cycle of origination and response between a pair of persons communicating through a computer-mediated channel. On the one hand, privacy may be violated through the exposure of activities that should be kept discreet. On the other hand, each one may be interrupted and distracted from their work by unsolicited information from the system. Generally speaking, every piece of information about a user may be considered private and should be protected from being revealed to others. However, this may not work when the social status and benefits of information of originator and receiver is dissimilar. For example, video is usually used to create a peripheral awareness in a distributed environment, somewhat like feel of sharing an office. Yet there is a danger that the video will be seen as surveillance equipment, rather than facilitation by mutual awareness, especially when the users of the system have different social and political status. To a large extent, the design principle of awareness systems is to be unobtrusive yet accessible. Unnecessary or irrelevant information about the situation of the work and other users may hinder work performance. There is a fundamental design trade-off between awareness support on the one hand and the privacy and disruption aspects on the other (Hudson and Smith 1996). Awareness support thus potentially results in problems both for the originator of the information (privacy) as well as for the receiver (disruption).

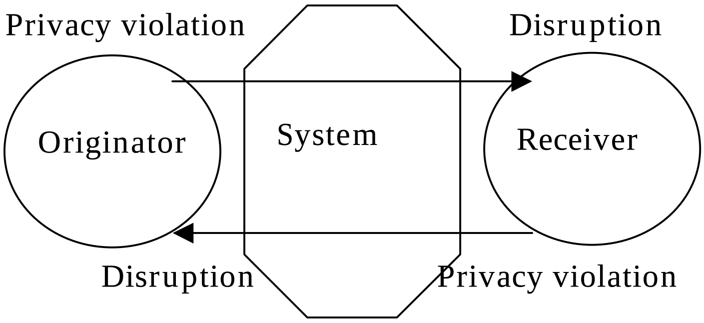

FIGURE 7 Schematic view of privacy violation and disruption

There is another particular situation for the unsuitable provision of awareness. It has to be noted that even if these problems discussed above have been considered or even disregarded, an intensive disclosure of others' activities is not always helpful and beneficial. Weisband (1994), for example, presented a good example concerning the awareness issue. Weiband discussed how a group decision was potentially influenced by the mutual awareness of the participants' social statuses and individual decisions.

> "Increased awareness benefits those who would also be opinion leaders in face-to-face discussions, while anonymity helps less dominant participants. Depending on some particular situations, increased mutual awareness may or may not be a desired effect. Usually this situation occurs when the anonymity is much more concerned and essential. This shows again that awareness support is a complex problem that has to be studied with great care" (Sohlenkamp 1999, p. 59).

2.3.1 Privacy Violations

Privacy has been recognized as an important issue originally from the studies of video conferencing and media spaces. In such an environment, video techniques are used to present one's activity to other people. Naturally people dislike presenting all the details about their activities. Furthermore, different types of people have different privacy orientations. If we handle all persons the same way, there is possibility for the infringement of individual privacy. This is due to the different degree to which persons perceive their information to be private. The greatest difficulty is to find a balance between the need for privacy, and the need to provide essential information for facilitating cooperation. Clement (1994, p. 87) remarks: "It is an intrinsic feature of all CSCW applications that detailed information about personal behavior is made available to others", and "the fine grained information about individuals' activities useful for cooperation and optimizing collective performance also may become a threatening resource in the hands of others." Dourish (1993) studied a media space and observed "privacy protection made the system more open" (p. 130), and the reasons are "they now trusted that a system was in place to protect their privacy if they wanted"; "the presence of feedback in the system meant that users felt they could be part of the system without the original feeling that they didn't know what was going on", and "the use of different services to delimit the space meant that users could make themselves selectively accessible".

An alternative approach, discussed by Greenberg and Kuzuoka (2000), is using physical devices (called "surrogates") to capture and present a remote person's activities, which still satisfy awareness design goals. They claimed that "surrogates can mitigate concerns about distraction and privacy because they can portray limited and abstracted representations of another's activities, and because they can present different degrees of salience" (Greenberg and Kuzuoka 2000).

Indeed, as previously stated, different people have different privacy orientation. However, privacy concerns will become less when people start to trust the system that provides the control on privacy. That means, privacy issues cannot be solved completely by technical solutions alone, but social issues such as group harmony and personal intimacy may overcome the fear of privacy violation.

2.3.2 Disruption

Information disruption may cause the disorder of people's work and distract their attention to irrelevant awareness information. As Furnas and Bederson (1995, p. 234) put it, "big information worlds cause big problems for interfaces. There is too much to see". It is significant to determine carefully the information transmitted between people in cooperation, because the system needs to provide awareness without intruding on the privacy of the originator or creating a disturbance for the receiver (Hudson and Smith 1996). In talking to workspace awareness, it is mandatory to assure the coherency of the group and environment. For example, when a person works on a document, s/he must discover which parts are the last changes updated by other users, and perhaps some extra information like the notes and comments may also be presented. This kind of information should not be treated intensively as an information overload. However, constant notification of changes made by the others in a synchronous co-authoring system may clearly interrupt everybody from their normal processes of editing. Many filtering solutions had been deployed and studied in a number of prototype systems, especially in media spaces where live video is used as a means of providing high-fidelity presence and availability awareness (Hudson and Smith 1996; Zhao and Stasko 1998). In summary, the dual trade-offs between sending awareness information and privacy, and between receiving awareness information and disruption or resource consumption, seem to be fundamental at some level.

> "The more information sent by a person the more their co-workers can be aware of that person. However, the more information one sends, the greater effect this can have on one's privacy. Similarly, the more information one receives about others, the more aware one can be of them.

> However, this information then also has greater potential for the disruption of "real work", either by direct interruption, or by consuming resources needed elsewhere" (Hudson and Smith 1996, p. 256)

The trade-off involving the information sent and received always exists.

2.4 Awareness Mechanisms and Design

All the information required for providing awareness to other users has to be acquired by a system. It should preferably not be necessary to request it explicitly from the user, but should be automatically collected in the course of the user working with the system. On the other hand, awareness information must be presented to other users when it is needed and in a way that it can be perceived without causing information overload and disruption. Awareness information is composed of a static representation of the work situation as well as dynamic notification about particular activities. Notification can occur in different ways depending on concrete user requirements.

Dourish and Bellotti (1992) clearly addressed the need for awareness mechanisms for ensuring collaboration among people. They discussed awareness support mechanisms in three types:

- Informational mechanism: refers to "providing explicit facilities through which collaborators inform each other of their activities" (Dourish and Bellotti 1992, p. 109). For instance, e-mail systems could be integrated with an authoring system.
- Role restrictive mechanism: refers to "describing an individual's relationships to the shared work objects and to other participants, and is typically linked to a set of operations which can be performed" (Dourish and Bellotti 1992, p. 109). That means a system should explicitly provide the cues to indicate the current roles of participants in a dynamic (or even live) way. The appropriate roles in a dynamic system are usually in change and obscure that can lead to uncertainty in the process of decision-making. Explicit awareness support would enable effective action-taking among participants.
- Shared feedback: refers to "automate collection and distribution of information, to present it as background information within a shared space" (Dourish and Bellotti 1992, p. 112). The emphasis of this mechanism is to decrease the workload of information provider and receiver on both sides via an automated feedback system.

Usually there is a common problem concerning the information delivery, such as delivery being controlled more by the sender than by the recipient. The problem is that the sender cannot predict what and how much information will be needed or the proper time to pass it on (Dourish and Bellotti 1992, p. 109). The shared feedback mechanism is especially beneficial to the concept of workspace awareness both in synchronous and asynchronous systems. In asynchronous systems, the primary task of awareness information is the use of historical notifications, or “change bars” (Dourish and Bellotti 1992, p. 113),

Gutwin, *et al.* (1996a, p. 287) presented a general set of information-gathering mechanisms that can be used for the maintenance of situation awareness, especially workspace awareness.

- Direct communication: refers to explicit communication about group members’ activities within the environment.
- Indirect production: refers to the indirect communication that is not presented explicitly, such as actions, the artifacts.
- Consequential communication: refers to the context understanding by "watching or listening to others as they work".
- Feedthrough: refers to the implicit understanding by observing the effects of someone's actions on the artifacts in the workspace (Dix *et al.* 1993).
- Environment feedback: refers to the implicit understanding by observing the environment.

Chen *et al.* (1996) presented four main dimensions of design considerations for use in constructing awareness maintenance artifacts for web users:

- Locus of Responsibility: Server-Side, Client-Side, or Centralized Dispatcher.
- Level of 'Work Group' Hierarchy: Group, Organization, or Community.
- Method of Locating Changes: Browsing vs. Targeting.
- Complexity of User Interaction: Simplicity vs. Customization.

The first dimension, the locus of responsibility, differentiates who is responsible for the record-keeping mechanisms for supporting awareness maintenance. Various information systems, such as the web, use the client-server model to partition the computational division of labor. Similarly the locus of responsibility for awareness maintenance at every level can be divided into originators (i.e., providers) of information, retrievers of information resource, and information retrieval and exchange intermediaries. The second dimension, the level of the 'work group' hierarchy, reflects the need for maintaining mutual awareness among members in various collaborative arrangements. Situation awareness is essential at every level above the individual level in the system hierarchy as is that originators and retrievers of information are situated at the opposite ends of the channel and net information subsystems. In the third dimension, the method of locating changes, involving two different ways of locating documents that have been changed: browsing (“at a glance”) and targeting (“specified” information). Finally, the fourth dimension, the complexity of user interaction, denotes the mechanism’s usability in terms of simplicity vs. customization.

Notification services (see FIGURE 8), introduced by Patterson *et al.* (1996) and Ramduny *et al.* (1998), provide shared data to a collection of clients and notify those clients whenever one of the items changes. Centralized designs were suggested and used in both papers, as Ramduny *et al.* (1998) explained:

"Each application that updates shared data can be responsible for notification, and consequently broadcast to all interested parties that the change has happened. However, as with peer-peer methods for data replication, this has a high overhead in both algorithm complexity and network load. For instance, every participating client program should know about all others in order to broadcast change information to them. Furthermore, the changes must be kept up-to-date as users join and leave the system. So, for just the same reasons that data stores are often centralized, there is a need for notification servers to keep track of interested parties and take over the task of propagating change information. Such notification servers may either be coupled closely with the data store, as is the case with some databases supporting triggered actions, or they may be entirely separate, knowing about the data but being decoupled from it" (Ramduny *et al.* 1998, p. 227).

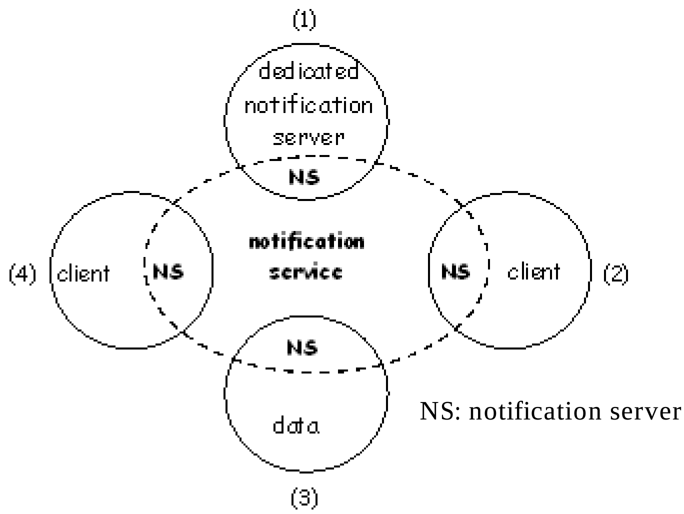

FIGURE 8 Location of notification server (Ramduny *et al.* 1998, p. 236)

Ramduny *et al.* (1998) identified four major implementation options for notification services:

- The notification server is closely bound to the data repository: The notification server must reside in the same physical address space as the data store or the data must at least be part of the server. An example is a database supporting triggered actions. Instead of having the notification server explicitly asking for the changes, the data store informs the server about them.
- The notification server and the data repository are loosely coupled together: In software engineering terms, the notification server is regarded as a separable component which may reside in the same physical address space as the data store but which may also sit somewhere else on the network.
- A distributed peer-peer notification service: Often a conceptual notification server is realized as a software abstraction within a group of

clients using peer-peer communication. An extreme example is the Aether system (Sandor *et al.* 1997), which percolates awareness information from node to node in a network, thus effectively providing an emergent distributed notification service uniformly throughout the network.
- A hybrid of the above.

In practice, systems may include elements of all the above three options. For example, a single notification server may be running on the network but a notification service component or agent may be integrated within each client in order to provide an effective application interface.

2.5 Emergence of the Network Community

Community, defined as a unified body of various kinds of individuals who interact with common interests (Merriam-Webster Online 2002). Network community, according to the definition of Mynatt *et al.* (1997), deals with establishing and working with meaningful connections between people. Technology thus has played an important role in this (Dourish 1993). In the last decade, network-based systems have been designed to support various aspects of collaboration, coordination and community. Applications such as email, newsgroups, bulletin boards, and shared task tools are just a few examples. These systems have all been useful in collaboration and further, in supporting the sense of a community, yet they also share similar limitations that could be addressed by developing network-based community support (Mynatt *et al.* 1997):

- Point-to-point connections support direct individual interactions, not multiple connections within a group of people or various groups to establish a shared context on an ongoing basis. Multicasting or even broadcasting approaches may support multiple types of communication across the boundary of point-to-point limitation.
- Task-focused or work-modelled connections can be too narrowly specialized to be able to handle ad hoc and unanticipated group activities as well as evolution over time, for example, the transformation of membership and relationship.
- Unbounded and uncertain connections, or high turnover participation make it difficult for groups to establish and maintain common awareness, group coherence, shared experience, and trust. Information availability and contact signal become significant under such a community type featuring transient relationship and quick unscheduled spontaneous interaction.

The definition of a network community focuses on the loose consensus and relationship about the notion of a community as a multi-dimensional but cohesive social group that includes, "in varying degrees, shared spatial relations, social conventions, a sense of membership and boundaries, and an ongoing rhythm of social interaction" (Mynatt *et al.* 1997, p. 210).

2.5.1 Internet as the Infrastructure of a Network Community

Efficient collaboration, no matter whether internal or comprising several parties scattered geographically, demands that the parties involved have access to the same information through a consistent infrastructure. The Internet has grown out of a continuing process of linking together smaller networks and separate computers.

Before looking at what the Internet is today, a brief look at how it all started may be helpful. The Internet, once popularly known as the Information Super Highway, is not new. It actually originated in 1969 as an experimental network by the Advanced Research Projects Agency (ARPA) of the US Department of Defense. The network (originally called ARPANET) was designed to enable granted scientists to communicate among themselves. ARPANET originally consisted of four computers, but by 1972, 50 universities and military research sites had ARPANET access (Wagner 1995).

One notable theme of the early planners was fault tolerance and reliability; as a result, ARPANET was designed to allow many routes among the computers so that a message could arrive at its destination using one of several possible routes, and not a single fixed path (Wiggins 1994). Therefore, if one computer went down, others could bypass it and continue to talk with one another.

With all of the computers being interconnected, designers had to develop a means by which these various computers could speak the same language. Their solution was to develop a communications protocol, which eventually became known as Transmission Control Protocol/Internet Protocol (TCP/IP). TCP/IP became the standard protocol used by the Internet in 1983 and remains the standard to this day (Ruthfield 1995).

During the 1980s, several other networks (including a National Science Foundation network of five supercomputers) sprang up. Eventually, all of these public and private networks were interconnected to enable any computer on one of the sub-networks to access computers anywhere in the entire network (Ruthfield 1995). Today, the Internet combines networks of academic, military, government, and commercial entities from the United States and over 40 countries.

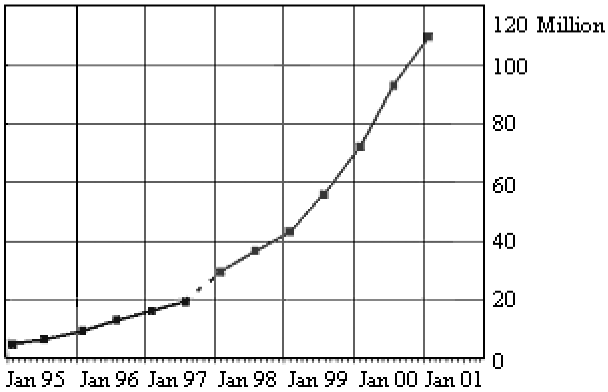

FIGURE 9 Internet hosts 1995-2000 (Lottor 2000)

In recent years, the number of computers connected through the Internet has grown from some 28 thousand at the beginning of 1989, to over 16 million at the beginning of 1997, and 43 million in 1999. By June 2001, this number had grown to almost 150 million. The growth factor has been slightly shy of doubling every year for the past 13 years. Assuming growth continues at this rate, the Internet will involve nearly a billion interacting devices worldwide by 2006 (Cerf 2001). FIGURE 9 shows the states of the Internet hosts from Internet Software Consortium (Lottor 2000).

The size and rate of growth of the net has already made it a substantial medium for communication. Universities and other research organizations were the primary source of the initial growth of the net, while net access became routinely available to scholars in the late 1980s, and to the general public in North America and parts of Europe in the mid 1990s.

2.5.2 Capability of Internet Collaborative Applications

Using the latest technologies is always a priority in enabling better collaboration when we design CSCW systems. New technologies are being developed faster than ever before. The ease with which we collaborate today has dramatically affected the frequency in which we do so (Campbell 1997). To make the best use of Internet technology, however, we must understand what it does. At its most basic, collaborative technology should:

- facilitate interaction between individuals;
- facilitate interaction between workgroups;
- enable users to communicate synchronously in real time through chat rooms, whiteboards, videoconferences etc.;
- enable users to communicate asynchronously at different times through e-mail, newsgroups, calendaring, workflow systems etc.;
- act as an information repository that can be accessed on a per-project basis, by authority and so on; and
- enable real-time teamwork, such as brainstorming or voting, between geographically dispersed staffers.

More specifically, the current Internet products perform a wide variety of tasks. These include: calendaring and scheduling; group contact management; e-mail; web-based publishing; web-based video conferencing; project management; security; data storage; data search / retrieval; data sharing; voting / polling; task delegation; and time billing. Some of the characteristics of the Internet technology enabling collaboration are outlined in TABLE 3, modified from Campbell (1997).

TABLE 3 Characteristics of Internet technology enabling collaboration

Characteristic	Description	Internet
Efficient	Allows immediate sharing of communication	Internet provides a uniform and standard distributed platform within which people can share information easily and efficiently
Organized	Allows information to be shared in a logical manner	Information can be shared and centralized in a logical manner using HTML / XML
Timely	Keeps information content current and appropriate	Keeps information content current and appropriate
Available	Can be used 100% of the time	Can be used 100% of the time
Access	Ease of access	Uniform information browser and easy to get access to information
Time Independence	Collaborate at any time	Collaborate at any time, either asynchronously or synchronously
Place Independence	Collaborate anywhere	Collaborate anywhere, even with wireless devices (e.g. mobile phones, PDAs)
Self-Documenting	Tracks the history of communication as a by-product	Ease of information uploading and downloading (exchanging)
Emotional	Captures the emotion of the collaborator	N / A
Imaginative	Captures the imagination of the collaborator	N / A
Brainstorm Enabling	Supports new idea generation	Supports new idea generation
Iterative	Allows iteration toward better ideas and understanding	Allows iteration toward better ideas and understanding
Indexed	Allows past communications to be easily reviewed	Allows past communications to be easily reviewed
Scaleable	Allows many to collaborate simultaneously	Easy to scale
Precision	Allows for a precise representation of facts	Multimedia representation of information (e.g. pictures, audio / video clips, 3-D images)
Immersive	Captures the full attention of the senses	N / A

2.5.3 WWW as a Network Community

> “The World Wide Web (W3) was developed to be a pool of human knowledge which would allow collaborators in remote sites to share their ideas and all aspects of a common project” (Berners-Lee *et al.* 1994, p. 76).

The World Wide Web, referred to as WWW, W3, or simply the “web”, is an Internet-based global information space begun by Tim Berners-Lee at the European Laboratory for Particle Physics (CERN) in Geneva, Switzerland. First proposed in 1989 and released to the Internet community in 1991, the web represents the "universe of network- accessible information, an embodiment of human knowledge" in hypertext and multimedia form (Berners-Lee *et al.* 1992; Berners-Lee *et al.* 1993). The web is the first example of a hypermedia computer-mediated environment with a body of software, and a set of protocols and conventions that make it possible for people on the Internet to search, retrieve, browse, and add information to the environment at will.

The web consists of notes or "sites" which information providers build on servers and people visit. Web sites are accessible through the use of client software, known as a web browser. People visit a site by entering its web address, known as Universal Resource Locator (URL) in the browser’s address bar or clicking on a hypertext link linking to some other sites. On the web, web navigation consists of visiting a series of web pages in a single site or several sites in order to search for information such as reading advertising about products, browsing content, or placing an order for a product online through the web browser.

In contrast to the web, Grudin (1988) cites various reasons for the failure of CSCW systems. One of the principal problems is obtaining a critical mass of users. Let us consider the cost-benefit trade-off for a user of a CSCW system presented by Alan Dix (1996). The costs of use are often constant irrespective of the number of other users. Actually web-based systems usually cost much less than traditional systems because the costs for dedicated client tools have been cut off by the use of web browsers that are usually free of charge. The benefit of the use of the CSCW system, to the contrary, rises with the number of other users. If there is only one user, like in a single user application, then there will not be much benefit from a CSCW application. However, it is still advantageous to use web-based systems as a central interface and access point to wider web services if no one else does. For a CSCW system, if there is a small number of users, the cost for each user is likely to exceed the benefit; only when there are a large number of other users does the benefit exceed the cost. The cross-over point is called the critical mass (see FIGURE 10).

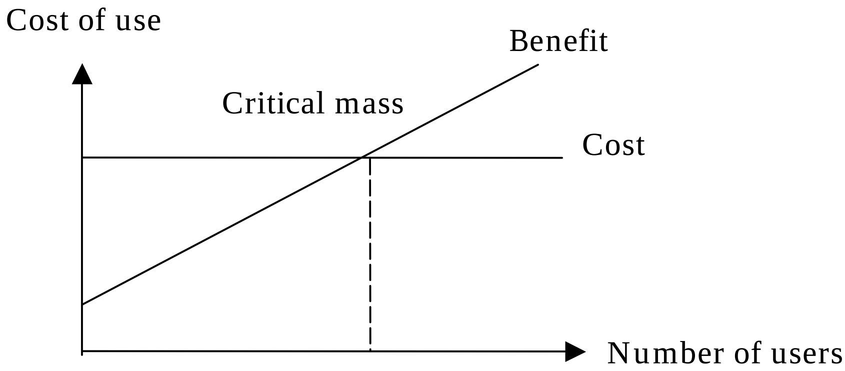

FIGURE 10 Cost / benefit of collaborative systems (Dix 1996, p.146)

Below the critical mass of users the cost exceeds the benefit, any sensible or early-adapted user will likely abandon the system, further reducing the number of users. Above the critical mass, where benefit exceeds cost, people will stay with it and others join. The challenge is to get to that critical mass position (Dix 1996).

Currently, over 162 million hosts are connected to the Internet worldwide (Wizards 2002). According to the Computer Industry Almanac (Computer Industry Almanac 2001) there were 533 million Internet users in the year 2001 (16.0% wireless internet user share). This is expected to rise to 945 million users by the year 2004. The latest survey was completed in January 2000. In terms of individual users, many people ask how many users are connected to the Internet and the answer is always an estimate- somewhere between 40 to 80 million adults globally distributed on arguably one of the most important communication innovations in history. See TABLE 4 for the Internet survey made in 1999 from Survey.Net (2000).

The continued growth of the web would have some implications. There are several famous "laws" about the great amount of users: Moores' Law, Metcalfe's Law, the Law of disruption, and Reed's Law. Gordon E. Moore, the chairman of Intel, observed that the complexity and the capacity of state-of-the-art microchips had doubled every 1.5 years since the introduction of the first planar-process transistor in 1959. Moore suggested that this doubling would continue in the future. The Law of Robert Metcalfe, a 3Com engineer, stated that the usefulness, or utility, of a network equals the square of the number of users. The Law of Disruption is from the book "Unleashing the Killer App" (Larry and Chunka 1998): "Until a critical mass of users is reached, a change in technology only affects the technology. But once critical mass is attained, social, political, and economic systems change" (Boyd 2000). Metcalfe's Law, however, is only partially correct. If users can not find their information needed or use the technologies provided from the Internet, the usefulness of the Internet diminishes. David Reed's Law (Reed 2001) beyond Metcalfe's law by introducing the concept and value of network community. Metcalfe's Law counts only two-person connections. In fact, people would form any types of connections for the purpose of communication. The value of the Internet thus depends on the numbers and sizes of conversational groups. The value increases as groups increase.

TABLE 4 User demographics on the Internet

Educational Background	Primary use of the Internet
[5674] 36.3% - College [4541] 29.1% - College Graduate / Bachelors Degree [2632] 16.8% - College Graduate / Masters Degree [1159] 7.4% - Some High School [1039] 6.6% - High School Graduate [545] 3.5% - College Graduate / PhD+ [25] 0.2% - College Graduate / PhD	[7745] 49.6% - Research [3430] 19% - Entertainment [2328] 14.9% - Communication [1361] 8.7% - Sales / Marketing / PR [747] 4.8% - Education
Best feature of the Internet	**Most-used Internet application**
[5918] 37.9% - Size of the network [3013] 19.3% - Quality of information [1868] 12.0% - Multi-cultural / world-wide [1551] 9.9% - Communication speed / performance [1352] 8.7% - Array of features / client applications [1027] 6.6% - Lack of regulation [885] 5.7% - Cost to use	[8768] 56.1% - WWW [4383] 28.0% - E-Mail [483] 3.1% - Newsgroups [378] 2.4% - IRC [173] 1.1% - Telnet [137] 0.9% - Other [75] 0.5% - Ftp [31] 0.2% - Gopher

2.5.4 Characteristics of WWW Technology

The web was originally intended to support a richer, more active form of information sharing than is currently the case (Horstmann and Bentley 1997). Early temptation and implementation of browsing pages is becoming very common today. The browser-level support of visitor annotation and the flexible addition of links between arbitrary pages by every web visitor are getting more attention by researchers (Berners-Lee 1992; Horstmann and Bentley 1997).

Web sites can be used for many types of collaboration. For example, a project team may need to keep track of project status and individual progress; people with a common interest (e.g., film enthusiasts) may want to share and discuss their views on that topic; a customer support group may need a system to provide online answers to real-world customer problems in electronic commerce sites; or several authors may wish to work on a document together via web technologies.

Although many existing groupware technologies and applications such as Lotus Notes can provide such services within organizations, "problems arise when organizational boundaries must be crossed, and issues of integration and interoperability with different computing platforms, databases and other application software need to be addressed" (Bentley *et al.* 1997a, p. 825). The popularity and rapid growth of the Internet and the web have created an open, universal, and easy-to-program infrastructure that can readily serve several groupware functions such as user and group management and lookup; discussion, document sharing, newspaper, and calendar discussed by Chiu and Griffin (1996). Under this context the web technology certainly has a number of distinct features as the basis for tools to support collaborative work. Principally web technology consists of the following key elements, originally following from Bentley's work (Bentley *et al.* 1997a):

- Hypertext Markup Language (HTML), which is a text-based language for information formatting and rendering. HTML defines basic structured information based on display-centric architecture. It deals with the layout of the user interface;
- Universal Resource Locator (URL), which is a convention for the location of web pages on the Internet. The URL contains the protocol of the resource (e.g. http:// or ftp://), the domain name for the resource, and the hierarchical name for the file (address). Systems can easily fetch various documents on the web via the use of URL because URL can point to other programs rather than simple HTML documents;
- Hypertext Transfer Protocol (HTTP), which is an underlying client-server (point-to-point) protocol to transport information associated with a URL. It is designed to reduce the complexity and heavy speed necessary for a distributed collaborative heterogeneous network. HTTP is general stateless and works typically under a fashion of "request-and-response". HTTP simplifies the communication protocols between different application and platforms, because every program theoretically can communicate with the others located in different hardware platforms if all of them can work as a pair of web browser and server;
- Web browser, which is a client-side program that is used to render and display HTML documents, and support other browsing-related functions. Nowadays web browsers are available almost for all popular computing platforms and operating systems, providing access to information in a platform-independent manner, and offering a simple user interface and consistent information presentation across these platforms (Bentley *et al.* 1997a). Web browser is becoming the de facto universal application for various tasks on the Internet because it has been already part of the mainstream operating systems and requires no additional installation or less maintenance effort for users. A browser plug-in is an application that helps a web browser to interpret certain types of responses from a web server. For example, a Flash plug-in is used to play Flash movies and a MPEG plug-in can play MPEG movies directly within the browser.

- Web server, which is a server that responds to requests for information from the web browsers. Many organizations have also installed their own web servers or designated their groupware to have good support for HTTP under the request of interoperation ability between different corporations and organizations.

Given these characteristics, the extension use of the web to provide richer forms of support for collaborative work is both appropriate and desirable. Despite the lack of direct support for collaboration, the current web protocols are designed initially for collaborative purposes and do decrease much of the complexity of deploying applications in a distributed, heterogeneous environment (Bentley *et al.* 1997a). According to Bentleys' analysis, the most common method of doing this is to use a standard technique called the Common Gateway Interface (CGI) (NCSA 1998)--with an extended capability to interface external applications with Web servers. An application on the web server side can thus be executed invoked by the CGI request and output dynamic information which can be displayed by a web browser, e.g. HTML texts. Along with this method, people can take advantage of the existing base of browsers as client programs for their collaborative applications. Standard web browsers, however, have innate constraints from the original design philosophy of an intuitive and individual information reader. These constraints inhibit the use of some kinds of applications, summarized as follows, mainly according to Bentley' paper (1997a):

- Continuous media: HTTP can support audio and video continuous media via browser plug-ins. However, real-time data updating is important to collaborative application. The web is an example of pull technology. But the push model of web publishing would offer many advantages to both the users and information providers, particularly where the web server needs to play an active role. An example of push technology on the web is for stock price and sports scores, but it can be used for all types of things to keep people informed. So far HTTP protocol enhancements to facilitate "push" distribution has been submitted to W3C.
- Information replication: Information is constantly updated to reflect people's current states of knowledge on their portions of collaborative tasks. The need to keep up with the most up-to-date and relevant information has become more important as the community expands. The web architecture provides no direct support for effective data replication as its peer-to-peer communication.
- Peer-peer communication: At present web technology lacks direct support for diversity communication such as server-to-server, server-to-client, or client-to-client, which is a problem of data replication and system scalability.
- Rich user interfaces: Although HTML supports basic features such as simple form-filling widgets, neither is it completely a user interface

toolkit, nor page description language like Postscript or PDF, and the complex user-computer interaction is limited.

2.5.5 Awareness Support as a Basis for Collaboration on the WWW

One of the major problems of collaboration on the web is that of coordination signals. In other words, how can we maintain awareness between remote research partners when changes occurring in one location affect activities in another?

Harrison and Dourish (1996) present a principle of "space is the opportunity; place is the understood reality". They present some features of space which can be applied into the case of web.

Relational orientation and reciprocity: The spatial organization of the real world focuses our common orientation, as we know that space is physically structured for others in just the same way as it is for ourselves. Hyperlinked web sites, for example, can be seen as a space that has a strict, static, and narrow orientation to all users. Referring to "click the right index to get the document" or "the document is after the front-page headings" relies on mutual spatial orientation, even thought the orientation is hardly visualized in users' computer screen.

Proximity and action: In the physical world, people act within a close distance. Understanding proximity helps people relate to each other and their activities. Similar properties can be exploited in 3D virtual spaces of web sites, for example, different metaphors can represent various types of proximity and the levels of activities of web sites inside the virtual space.

Partitioning: Distance can be used to partition activities in space. Web pages are naturally used to partition web site space. A web page is the location of all action occurring within certain proximity and can have differences in the different site (space).

Presence and awareness: The sense of other people's presence and the ongoing awareness of activity enable people to structure their own activity, "seamlessly integrating communication and collaboration ongoingly and unproblematically" (Harrison and Dourish 1996). This type of awareness can be place-based and / or space-based.

One manifestation of virtual cooperative interaction on the web is that of the web page in general, or homepage. The proliferation of web pages with cross-linkage of other sites by people who share common interests has made the exploration process on the web, i.e., net surfing, "a social experience. Such a seemingly intrinsic rewarding experience can often be characterized as serendipitous and not necessarily task-oriented as in traditional groupware" (Chen and Gaines 1996b). Through web pages, for example, individuals can publish their own information on the web without any awareness of who their eventual audience might actually be, i.e. without extensional awareness of particular recipients. However they often have a sense of who the potential audience might be, i.e. with intentional awareness of the type of recipient (Chen and Gaines 1996b). This phenomenon exactly mirrors the real situation. However, people can get social feedback or cues regarding their presence and activity from their audience instantly, or slowly. People, however, can hardly get this type of awareness information with respect to their web pages. At least the present underlying web technologies do not support it directly.

Quite often collaborations on the web involve user interactions without pre-planned coordination. In fact, users on the web may or may not have the intention of getting to know each other when they cooperate. It is the fact on the web so far that people are hardly aware of each other's existence until they have either direct or indirect interactions. Nevertheless, the interactive process between users is still loosely cooperative in nature. It differs from the traditional team-oriented cooperation where group tasks, goals, and purposes are usually well-defined (Chen and Gaines 1996b).

For example, a user is interested in buying some books from the Amazon.com online bookstore. Amazon offers a user interactive channel by providing a book review system, which enables users to post their relevant comments freely. Users in this case are aware that some other ones have checked out the site and some books. Nevertheless a user of the service is unaware of who else is actually browsing the same information resource at the same time. That is to say, there is lack of system support for mutual user awareness. While we expect the web to have more than one mode or communication channel for collaborative activities, it lacks at least one form of interactive mode that is analogous to conversation to support co-located peripheral awareness. Here the term "co-located" means virtual co-location, i.e., the collaborative activities occur in a non-physical space which allows participants to be situated in geographically separate locations.

2.5.6 Adding Situation Awareness in Semantic Web

An increasing percentage of web pages are dynamically generated from structured or semi-structured information sources such as databases or knowledge bases. Because the rendering of these pages occurs in HTML at the users' browsers, the original structure and linkage to some meta-data, if available, is missing, because the current standard of HTML has no such support. One of the most recent trends in the evolution of the web is the growing awareness of the need for a semantic web (Berners-Lee *et al.* 2001), a web of information that machines can understand and process. The semantic web is an extension of the current web in which information will be assigned well-defined meanings, better enabling computers and people to work in cooperation. The requirement to encode machine-interpretable information on the web has led to the development of a number of languages for representing this information. These languages originate from different communities that have different sets of requirements and goals in mind. The languages that are emerging have many similar features, but each of them is ultimately different from the others.

Standards such as Extensible Mark-up Language (XML) provide a convenient mechanism that has capability to describe information, rather than simply displaying information in HTML, and connect information providers more directly to receivers of semantic content. Nevertheless, XML is just a standard and is not capable of conveying semantics by itself. XML only conveys semantics to the extent that information producers and consumers agree ahead of time on the meaning of the XML tags. For example, the content designers and the browser designers, then embed their agreements into the programs that in turn act as the producers and consumers of XML content. FIGURE 11 tries to depict how a recipient manages awareness information from a possible semantic web environment.

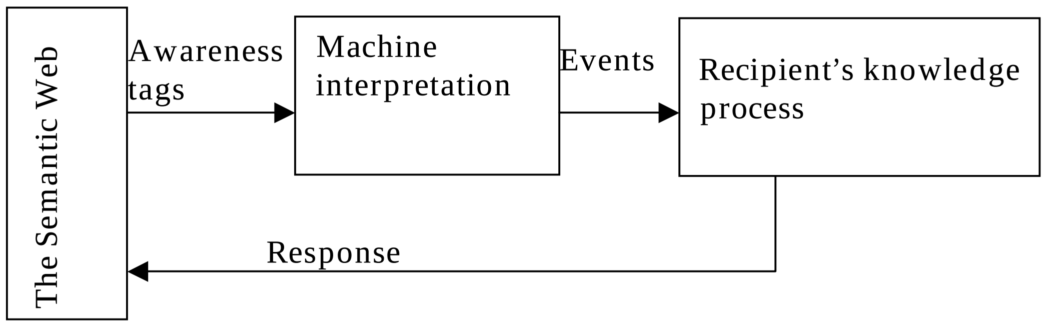

FIGURE 11 A proposed process of interpretation on the semantic web

There is a semantic interpreting tool between the web and the user, which interprets the semantics into events, a pre-defined and easily-understandable language for knowledge post-processing. To perceive the awareness events from a semantic web site, the recipient can use any program that understands specific awareness tags defined according to the XML syntax. For instance, an example web document containing the information about the number of users and their names can be written in XML schema:

```
<?xml version="1.0" encoding="ISO-8859-1"?>
<situation_awareness>
<user_awareness>
  <online_user>5</online_user>
  <name>Foo1</name>
  <name>Foo2</name>
  …
</user_awareness>
</situation_awareness>
```

Currently, there is no consensus on how and which language should be used as the standard, and researchers and developers continue to work with the existing languages and to develop new ones.

2.6 Summary

The growing availability of collaborative systems and services on the Internet has expedited innovative knowledge creation/dissemination processes. A major motivation behind the current research is to investigate the nature of distributed cooperative interaction among networked collaborators who use the Internet as an integral part of their working environments.

In this chapter we examined the concept of awareness in the context of CSCW and groupware, especially in the field of the online community, i.e. the web. The Internet, as a community founded on cooperation, will act (and has acted) as an infrastructure supporting global information exchange and human communication. The provision of awareness can support better coordination, and aid informal communication and formal conversation.

Awareness support in the web community is an important topic of research. The next chapters will go on to study the elements of awareness and the mechanisms underlying awareness in terms of human and technical factors. Awareness attributes and systemic features will be addressed and analyzed.

PART II: THEORY AND IMPLEMENTATION

AWARENESS DIMENSIONS

You, Yu (2000), A Survey for the Study of Awareness in Co-operative Systems, published in the Proceedings of the IRIS'23 Conference, Selected paper awarded, Vol. 2, Svensson L, Snis U., Sorensen C., Fägerlind H. Lindroth T., Magnusson M. & Östlund C. (Eds.) Lingatan, Sweden, pp. 1527-1539

MEETING OTHERS - SUPPORTING SITUATION AWARENESS ON THE WEB

You, Yu and Pekkola, Samuli (2001), Meeting Others - Supporting Situation Awareness on the WWW, published in the Journal of Decision Support Systems 32(1), pp. 71-82.

An early version of this article was published as:
You, Yu and Pekkola, Samuli (2000), Supporting Awareness of Other People on the WWW: framework and example, in the Proceedings of the Pacific Asia Conference on Information Systems (PACIS'2000), J. Thong, P. Chau and K. Y. Tam (eds.) Hong Kong, HKUST Business School, Hong Kong University of Science and Technology, pp. 44-58

THE DESIGN SPACE FOR WEB USER AWARENESS

You, Yu (2000), The Design Space for Web User Awareness, published in the Proceedings of the WebNet 2000 Conference on the WWW and Internet, San Antonio, Texas, Association for the Advancement of Computing in Education (AACE), CD-ROM, pp. 592-600.

AWARENESS AND REAL-TIME WEB USER COLLABORATION

Yu You and Mike Robinson (1999), User Awareness on the WWW, published in the Proceedings of the ICYCS'99 International Conference, Nanjing, China, J. Z. Luo, B.W. Xu, Y. Wang, X. M. Li, and J. Lu (eds.), Academic Publishers, pp. 980-984.

PART III: EVALUATION AND SUMMARY

7 EVALUATION

The preceding chapters have presented the concepts pertaining to SA, and the design and construction of a particular awareness system for use on the web. It is now time to evaluate this study of SA and its implementation according to the knowledge gained in the preceding chapters. For this purpose, this chapter, firstly, starts by describing two usability and case studies undertaken to test the awareness system in a large-scale user environment as well as in a more restricted and smaller work community, and continues with a discussion of the outcomes. Secondly, the requirements of CSCW and SA in general are reviewed and the present study is evaluated accordingly.

7.1 Usability Test

The focus of a usability test is the user's experience with a product or process. During a usability test, product development teams gather user feedback to improve product design. The result of usability testing is a list of specific and general recommendations for improving the product provided to the users. The difficulties of conducting SA evaluation, for example, usability test and longitudinal studies, are to find work situations where real-time distributed work has been undertaken and we are able to re-play the whole work process with the integration of awareness support to observe the difference. As per Markus Sohlenkamp talked about the problems of groupware evaluation (Sohlenkamp *et al.*, 2000), it may be possible and feasible to test the appropriateness of single-user applications under a closed and small group of people over a limited period of time.

> “Users can be tested in a laboratory on the perceptual, tactile and cognitive aspects of human-computer interaction that are central to single-user applications, but lab situations and partial prototypes cannot reliably capture complex but important social, motivational, economic, and political dynamics” (Grudin 1994b, p. 102).

The features of groupware applications are characterized by its interactivity and interdependencies between users. However, with the intention of better observation and evaluation of particular effects of situation awareness involved in normal systems and environments, we decided not to test the capability of situation awareness in a heavily interactive environment, but loosely cooperative one. We conducted a usability test in a real situation (a live web site) for several months following up user activity to see how the provision of SA can help people in different ways and add value to the site itself. The study used the method of simple observation to analyze how people use awareness widgets to aid communication. The overall test is open and no control is imposed on the "task" (game playing). This fits in exactly with the current web situation: most of the visitors to a web site do not know each other; there are no explicit or predefined tasks, or even compulsory rules and roles for such visitors. That is, there are very loose links among the visitors, even a lack of links between the site operators and their visitors. Entertainment sites, or e-commerce sites, for example, unlike general sites, are inherently willing to have a relatively "sticky" relationship, but nevertheless have to treat their visitors very carefully and unobtrusively, since they know how easily and quickly people turn away and never come back. Stickiness refers to the amount of time that uses spend on a site, and the ability of the site to retain repeat visitors who spend more and more of their time on a given site instead of briefly landing and then flying off to some other corner of cyberspace.

Often there are two ways to collect and analyze data: to prepare detailed experiments with users on a single site under controlled conditions, or to collect very large amounts of data about users across global multi-sites. Due to our limited resources we chose a single medium-sized entertainment site, PlayJavaGames (the game site)[8] for our evaluation study. Our awareness system had been used for providing user awareness in conjunction with those games for more than six months. The overall goal of the study was to gather information and understand how an awareness system can help a web site greatly by creating a shared online community, leading to quick and easy communication based on web pages. Rather little research has been done on the web-based use of awareness. In addition, the study also seeks to discover any technical and usability problems with the awareness system.

7.1.1 Case Description

The game site (see FIGURE 27) is a popular one that attracts more than a thousand visitors daily. It contains almost 400 various Java and Flash games, which are organized under 11 game categories. The reason for choosing an entertainment site for the evaluation of the present system is because the users of an entertainment site are more naturally social, seeking human-computer and human-human interactions, and are inherently willing to meet other game players, particularly for multi-user games.

---

[8] PlayJavaGame site, http://www.playjavagames.com/

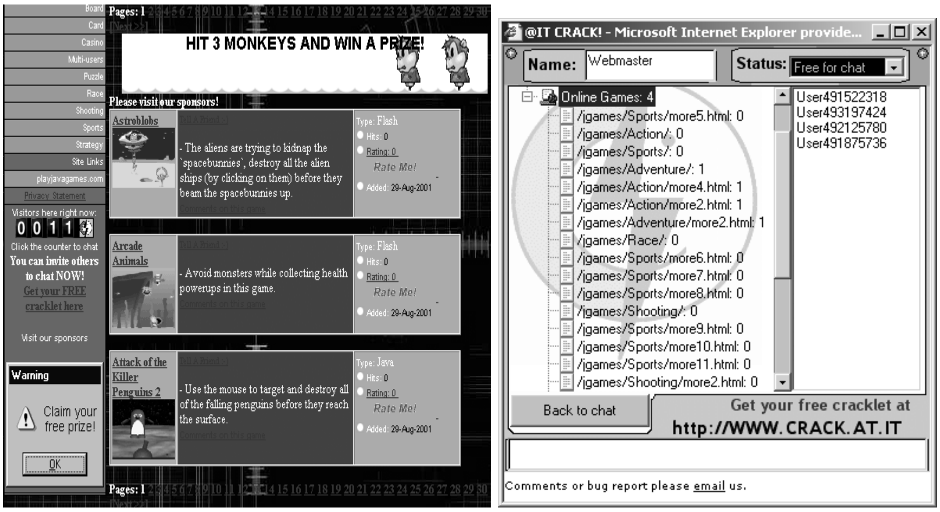

FIGURE 27 Testing web site

The challenge for user awareness support is to provide user activity information in an appropriate way or by a manner of presentation that won't disrupt their normal "social" processes, or de-motivate players from game playing, as this is a crucial factor to be a success. With standard web server technologies it is hard to capture rich information on users' visiting activities. Certainly, web server technologies can track down which pages are accessed by visitors, and which paths are taken through a site. Usually where visitors come from can be found out on the basis of their machine domain names or IP addresses, and where they have been before (the HTTP header information "REFERER"). However, these rather inactive snapshots cannot provide a timely fashion that is crucial for situation awareness support, especially for event notification and live overview of user activity.

To accurately track users' activities on the whole game site, a tiny awareness counter is placed in every page to record users' activities (see FIGURE 27 and the live counter on the left-hand side). The technical details of this tool have been discussed in previous chapters (see Chapter 4 and 6). The right-hand picture is the overview site activity map and user awareness and communication center. The site map tells us immediately where and how many users are at one web site, or at several sites within the same community (e.g. within a large corporation), depending on the server configuration. Normally, users stay on-site for more than 5 minutes and even longer than 10 minutes. People play games and keep the awareness counter running in the background, as this will not interrupt their activities like game playing, and bring up the user communication window instantly when needed.

7.1.2 Data Collection

First, the original data was collected and analyzed from awareness server log files. Two types of log formats were analyzed: raw access and communication. The raw access logs are similar to standard web logs that contain completed historical hit records for in-depth post ad hoc analysis of user activity and overall site performance. Communication logs contain all the conversation content that occurred during user communication, plus user IDs (most of them are anonymous and numerical names assigned automatically by the awareness system) and date/time. Communication logs are a very useful and valuable means for web site owners to catch up with up-to-date information or feedback posted by their web site visitors. In particular log information motivates site owners to update and improve their sites and services accordingly.

The test collected and analyzed log files for five months from June 01, 2001 to October 31, 2001. In total 57586 unique users (IP addresses) had visited the game site. They stack to the game site for usually more than 3 minutes and in some cases up to 10 hours. The average time was 3 minutes and 14 seconds. Interestingly there were 4833 players who stayed online for over 2 hours (of course, it is quite likely that some players stopped playing for a while but kept the game page open. There is as yet no technology that can remotely sense or control real non-computerized human activities). We deliberately opened a new pop-up window for every game so that people could still get awareness information and notifications, like the current live number of online users and incoming chat invitations.

The proportion of raw access and communication is given below (see TABLE 16). In total 7% of visitors showed intentions to check out the other visitors by using the site map and chat tool.

TABLE 16 Game site access log chart

Artifacts	Raw access numbers	Unique IP numbers*
Live counter	816175	57586
Site Map and Chat tool	6505 (0.07%)	4223 (7%)

* the number of visitor IPs gives us a more realistic information about the usage of the awareness system than the raw access numbers.

7.1.3 Chat Log Analysis

In total there were 10751 records in chat logs during the 5 months. 425 (4%) were private messages which took place in pairs (person-to-person). When a user opened the conversational center, the default was a public chat room. In order to have a private chat, you first decide the person you wish to talk to, and then send a “private” chat invitation to that person. Of course, you can invite anyone to the public room as well. One distinguishing feature of the present compared to other chat tools is the “invitation-to-page” function. That is, if nobody is in the public chat room, she or he is able to invite others who are on the same pages or sites to chat or join the conversation. This is an extremely useful feature for e-commerce sites or any sites that particularly need such pro-demanding communications. As a result marketing staff or salespersons are able to meet their potential customers online in their web pages and initiate a live conversation and answer any questions immediately, with less effort.

From the chat logs, the most often used texts are greetings like “hello”, “hi”, etc. at the beginning of conversations, exactly as in real world situations. The second most frequently used texts were like variations on the question “anybody here?”. Quite often the situation in chat rooms was that people dropped in, found that nobody was there, went away, and probably did not come back again. This exposed two important design flaws: firstly, people sometimes misunderstood the awareness information given by the live counter. The information presented by the counter is the numbers of current active page visitors rather than people in active conversation over the web pages; for example, one user left a message in the public chat area under the Education category: “User09788597: I don't think there's anyone else here but checking just in case”. It raised the question of how intuitive the interface could be. The original purpose of the awareness counter was to create a communication gateway that would smoothly lead people to live conversations, and reduce the effort to locate another different "place" to be able to meet and communicate with each other (see discussion in Chapter 4). Unfortunately, the current design apparently did not satisfy this requirement very well, as at least one individual was soundly confused. Secondly, people subconsciously expected to be heard by someone “far away” around the page/site, and this would bring more people into this chat room. This is a very interesting potential design feature that may be applied in future specific online environments.

As mentioned before, the pro-active chat invitation to users on the web pages proved to be as a feature that allowed conversation to happen even other users were not in the public chat room. In fact this function was intended to solve the “empty chat room” dilemma and has partially achieved its objective. Chat invitations can always be sent to others on different pages or even different sites once the awareness tool is installed. Certainly, as far as the issues of privacy violence and disruption are concerned, the awareness system has provided a privacy protection mechanism that enables receivers to refuse and disable incoming invitations at any time, or even conceal themselves entirely from the site map. The following invitation scenario was recorded in the logs: [Ron, a user who has opened the Site Map and has been waiting for visitors to his page, had posted several articles in his site and was hoping for feedbacks].

…

[ron noticed a visitor (User30569969) to his page and sent a private chat invitation to him/her]

ron: hullo, whos this?

User30569969: Satwik

[User30569969 changed his name to Satwik]

ron: what are you doin here

Satwik: reading the new article

ron: readin the latest on vijay>

Satwik: Yeah

ron: its me, ashu :) i was thinkin its somweone i can play a prank on

Satwik: But the chat invitation said it was U

ron: it did??? what the...i changed my name to ron for the express purpose of connin

Satwik: Anyways, I'm reading the article and so far its not that funny
ron: thats the part vijay wrote then
… (conversation texts omitted)
[After Satwik left, Ron found another visitor (User34360821), so he sent another invitation as well]
ron: hi, who be this
User34360821: hi
ron: ashu?
User34360821: nope
ron: then?
User34360821: friend of ahus friend!
User34360821: ashu i mean
[User34360821 changed nickname to Sandy]
Sandy: who is this?
ron: ths cool. where ya from. im from ny
Sandy: im from bombay
ron: ronak, im a friend of ashu's too
…

Sometimes people taught each other how to use this system through conversations and asked more awareness questions if the system did not explicitly provide[9], for example, questions like "who are you", and "where are you from", etc.

Niina: this is a private channel, how did you find it here?
Marie: You click on the person'name in the list and ask for a private chat
Niina: Is it in the first small screen that you click the name?
Niina: ok, I got it!
Niina: :-D
…
frankly: i like the counter showing current visitors.
frankly: :-)
frankly: does the counter change?
User23647217: :-)
frankly: am i talking to me here?
Aaron: HEY!
Aaron: Wazzup?
User88681471: hey whats up man?
User88681471: great site
Aaron: Nothin'. Who is this?
Aaron: Thanks.
User88681471: Kanon, i just found a link from some java help site
Aaron: Cool.
…

[9] This version of the awareness system did not recognize web visitors automatically. The system simply assigned a random meaningless name to every visitor.

snowwhite: fine, cool technique this chat applet.!
canary dwarf: Whats up, and who you are people? (-:
snowwhite: wheres this chat located?
Doog: wher are you
snowwhite: i think i came from playjavagames..
Doog: yep u did
snowwhite: i am in netherland:-)
snowwhite: (europe) and u guys?
Doog: i am in scotland
snowwhite: :-D
snowwhite: nodded.
…
snowwhite: this is realy cool. i wanna have this applet too...
snowwhite: i am @ home..
Doog: how old are u
snowwhite: u can just invite visitors from all over the page wow..
…
hotgirl1724: who invited me here?
hotgirl1724: opps
hotgirl1724: i'm here
hotgirl1724: hello??????????
…

7.1.4 Web Questionnaire

In addition to the log analysis, a web survey has been used based on questions about the use of the awareness tool five months after the installation of the awareness system. An online questionnaire (see Appendix II) was placed deliberately at the entry-page of the game site in order to force the players to answer those questions. The questionnaire contained only four single-choice questions to make the survey easy and simple. The survey continued one month long. In total the number of visitors of the test site is 12229 in one month, and the number of valid votes is 2961 in 4334 total responses, based on visitors' IP addresses. We observed that the result of the survey proved the consensus of satisfaction for most players and the usability of the tool is basically acceptable (see the result in FIGURE 28).

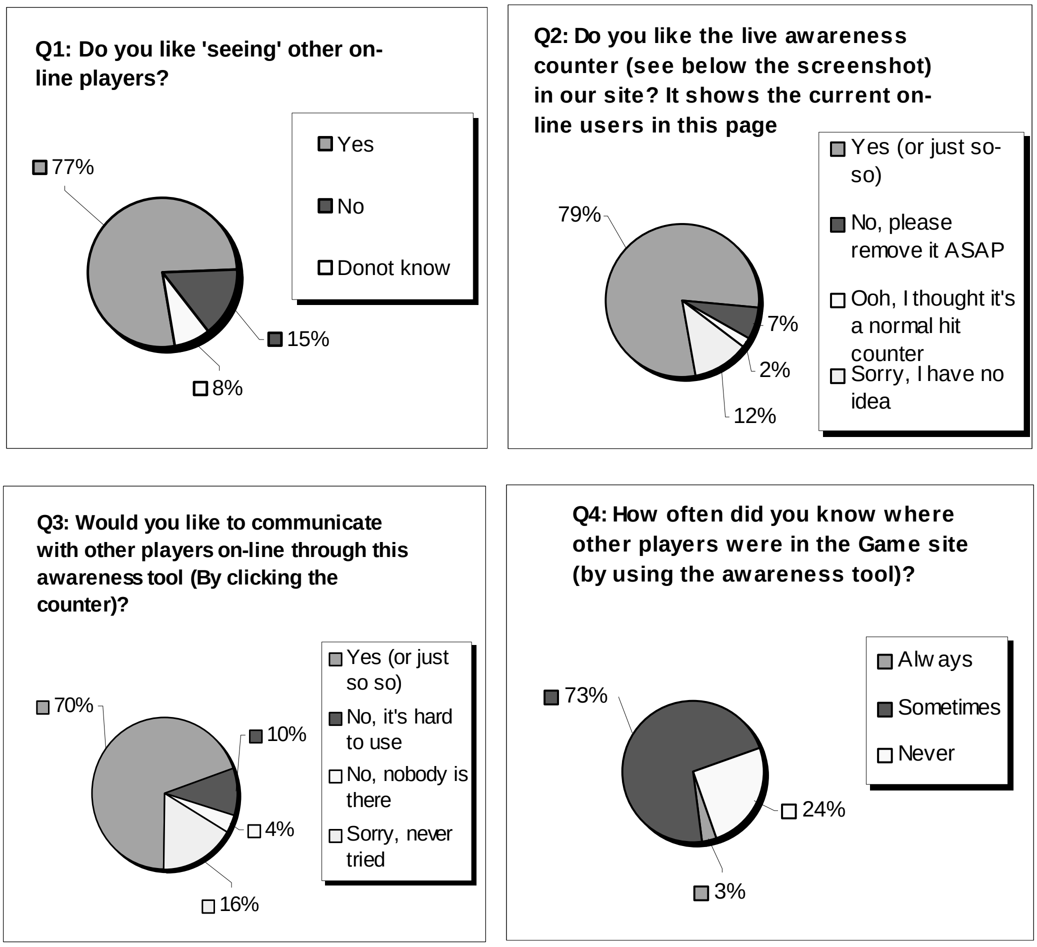

FIGURE 28 Usability survey result charts

7.1.5 Findings

The system increased user awareness of who is nearby. It is non-obtrusive (passive) and requires no particular operation from the users. Very interestingly, when the user hears the beep, (s)he knows immediately (of course, a newcomer is always curious about the sound) that someone is virtually “close” to him and feels very energized about it. It appears that normal web log analysis tools do not have such an emotional and lively effect on users.

7.1.5.1 User Interface Design

The way in which information is presented via the interface will largely influence awareness by determining how much information can be acquired, how accurately it can be acquired, and to what degree it is compatible with the user’s awareness needs. Hence, awareness has become a topic of great concern in many human factor design efforts. Determining specific design guidelines for improving awareness on the web through the interface is one of the challenges taken up in the present design. Some users reported that they mis-clicked the counter and were led to a page that was not what they supposed, since the counter contains two different areas: the number area and logo on the right.

Many users complained that they first thought the logo would be the click button to open the awareness center window but instead it led to our company's frontpage as it was configured. We used the similar interface of normal page hit-counters to represent the number of live visitors. The design philosophy was theoretically correct but in practice problematic. Most new users, if not all, ignore the awareness counter at their first glance simply because it looks so much like a normal static hit-counter, rather than a clickable and dynamic awareness artifact.

The site map is mainly used by users who are familiar with each other. The awareness system supports the persistency of names and shows the saved meaningful users' names instead of randomized tricky nicknames after the users have changed their names. Another noticed flaw is the plain user list in the site map. Such a simple list of users creates operational inconvenience when it is too long to be convenient for users to find out people.

7.1.5.2 Awareness of "what has happened"

The system is only capable of notifying events synchronously. While users are able to know that something is happening right now, they are not able to tell that something has happened over a time period. However, if a user temporarily leaves a particular site, all activities occurring during his absence will not be noticed by him. It is not because the system is unable to provide the awareness information, but rather a problem of presenting awareness information in a right way.

7.1.5.3 Critical mass problem

When we talk about meeting online, and illustrate an amazing utopia that would take place everywhere in all web sites, however, this is not the reality yet but our personal good willingness. We call this phenomenon the "critical mass" problem. Starting with a simple calculation, we assume that a web site has 25,000 times / visitor per month, no matter how complex the site structure is and how many web pages the site contains (the number 25,000 is not the web page hit). The average number of simultaneous visitors will still be only about 20 if each of these stays 4 minutes (the number of simultaneous visits would be much higher if they occurred during certain times of day: for example, from 8:00 in the morning to 16:00 in the afternoon). So it becomes a question of how to place the awareness system so as to maximize encounters. Alternatively, a bigger community would be created if multiple awareness systems (servers) could be inter-connected together.

7.2 Case Study

The case study is the method of choice when the phenomenon under study is not readily distinguishable from its context (Yin 1993). In order to determine the feasibility of the research design, a single case study was undertaken and the data was collected from the interviews with users at Siemens, Finland, a company that has been using the awareness system for more than half a year. The primary goal of this case study is to double-check the research concepts and hypothesis. The case study should reveal the strengths and weakness of the design, its applicability to real work situations, and its usability. The results of the case study can then be used to improve the existing capability of the design and create new capabilities.

I was interested in qualitative rather than quantitative results. I wanted to gather general impressions and gain insights into changes in users' working styles induced by the awareness capability. First, concerning the choice of appropriate research methods, the use of a structured complex questionnaire was ruled out for of two reasons: first I was not acquainted with the Siemens culture well enough to be able to ask the right questions regarding their work. Second, a questionnaire would have been inadequate because it would not have picked up on differences between what people say they do and what they actually do. Also, my pilot study, using an anonymous web questionnaire, did not yield enough valid data simply because people refused to answer my questions. I, therefore, decided that conducting interviews would be the most appropriate means of collecting both background data about Siemens work environments and specific data about awareness influences and impacts. The next decision was whether to conduct structured or open-ended interviews. The trade-off is that with structured interviews there is consistency in responses. On the other hand open-ended interviews would give me the opportunity to explore specific aspects of the Siemens culture according to the inclination of the respondent. That is, if an individual had strong feelings or views about the topic, we could explore it in more depth; for example, the value of organizational psychology was discovered through the open-ended interview technique. I finally chose a simplified hybrid interview method which included both a few structured questions and an ethnographic interview.

7.2.1 Case Description

> "Siemens is Europe's largest manufacturer and distributor of electric and electronic equipment with a world-wide network of production and marketing units. The product line includes investment goods such as public networks, medical equipment and power plants, as well as computer hardware and software systems and microchips. The Corporate Research and Development division provides innovative know-how for improving production processes and products. The Siemens infrastructure and product line requires general-purpose groupware to be used for management issues. Additionally important, specific groupware features will be integrated into production processes and products" (Völksen, 1997).

Siemens Osakeyhtiö in Finland is a fully owned daughter company of Siemens AG, Germany. Siemens Finland uses Notes as their coordination and communication tool. People share resources, schedule their time, and exchange messages such as emails via Notes. Of course, in Notes sharing is asynchronous even when users are accessing the same resources, like files in the same folder. The department I interviewed is the department of Corporation Communication (CC), which is responsible for corporate presentation, internal and web communication, and other publicity work. The department has been seeking for technologies to enhance their internal communication and make the whole intranet more efficient, as the term "business incentive" named by the manager of the CC department.

> "…in a large company, you are always having the problem that the resources are not fully utilized....I think one of the main ideas of awareness system is to make better utilization of the resources you already have. And especially the company like Siemens we have so many different business units, we have energy, industry automation, we can create complete power plans in the energy side, or compete food beverage plants from the scratch. It's very broad…I mean there's almost nothing that Siemens does not do…So if we can make all those people work together, more effectively, and the energy guys, industry guys, and those guys [means IT people] who do this, there is a great challenge but the problem is they don't talk to each other. There's no way they can inter-connect, but there's a chance, with this [awareness system], we can, in a case like this, we are small, we are just 1000 people, using the same language, we are, this is why Siemens Finland Intranet collaboration has great potential. We are speaking the same language, working for the same company, and we are in the same physical area…we are a team, a community" (Palosuo 2001)

The awareness system was installed in the Siemens intranet web pages. Much of the value of an intranet comes from making it a communications tool that all employees check every day (Nielsen 2002). The partners of Siemens Finland also can get access to the intranet via the extranet (see FIGURE 29). An interview was then used to evaluate the system and its impact on the Siemens work situation. At the same time the system log file was analyzed in the same way as in the previous feasibility study to complement the perceptual and attitudinal data.

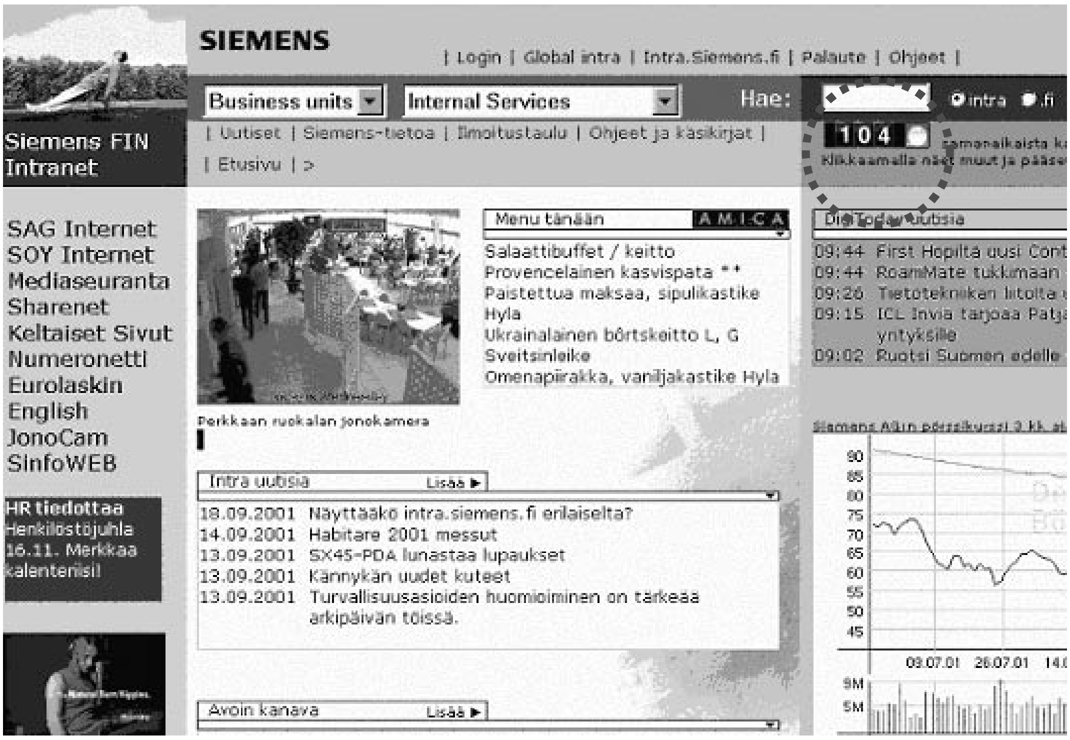

FIGURE 29 Siemens Intranet front-page

7.2.2 Findings

In total 2226 unique users[10] (IP addresses) were found in the log file (see TABLE 17).

TABLE 17 Siemens intranet user raw access table

Artifacts	Raw access numbers	Unique IP numbers*
Awareness Counter	228648	2226
Site Map and Chat tool	3196 (1.49%)	640 (20%)

They stayed online usually for more than 2 minutes (around 500 users) or even much longer, e.g. over 1 hour (around 120 users). The raw access and communication numbers are given below. All together 20% of users had clear intentions to check out the others by using the site map and chat tool. Compared to the ratio (7%) for the game site, the ratio (20%) in Siemens is clearly larger, because the users come from the same corporation and have more concrete objectives and reasons to be there, rather than just randomly seeking games. The novel user awareness function in Siemens intranet motivated people to be present and made the use of Siemens intranet more effective according to the interview with Siemens users.

[10] Only internal and authorized external computers have the right to access Siemens intranet. This is why the number of recorded IPs is such small.

An online anonymous questionnaire was used as a complement (see Appendix III). Those questions mainly were based on the aspects of direct observation, effects, and impacts influenced by the use of awareness tool.

7.2.2.1 Patterns of communication and collaboration

A central problem of cooperative working is that people are usually unaware of the thoughts, intentions, and feelings of, or “facts” available to others with respect to a particular issue (Robinson 1991). These are discovered in the course of conversations and discussions in formal meetings and informal encounters. A central property of conversation and discussion is that people change their minds (preferences, choices, viewpoints) in the light of the whole discussion. CSCW applications should reflect this. The awareness system would change if fully integrated with current systems, a situation that previously mislead the concepts of mutual influence: “when should we meet?”. Informal encounters and “quick and short” conversations and discussions resolved lots of problems and increased the mutual influence. TABLE 18 describes the work situation with respects to the requirements of coexistence, communication, and collaboration and coordination.

TABLE 18 Use patterns of current systems

Requirements	Current (previous) work situation in Siemens Finland
Coexistence	There is an international ShareNet application that works globally. People can check for other live persons internationally when and only when they have logged into the ShareNet member area. “The server is running in Germany…all online users…globally right now these people from Siemens companies [are] working on the web sites…[the number is]not very many as you can see”. In general, no system supports real chance encountering simply because people can not see each other in their most common working environment, i.e. web pages.
Communication	Siemens has Notes messages, video-conferencing, and web discussion boards for human communication. People often prefer to use emails and phone calls: “we use emails and telephone. So first [we use] use emails, people do not often pick up their phones. Of course if there’s some urgencies then I just call…and also [use] electronic calendar reservations”, and “emails, sometimes phone calls, emails is the most necessary case, and those [discussion] forums”.
Collaboration and Coordination	People use Note mails to exchange information, electronic calendar reservations for booking meetings, internal documentation systems for file sharing and which are integrated with Siemens ERP systems.

One difference we observed is that after the introduction of awareness support people created a daily routine of “trying to check who is there”. The reason for checking for online users is the desire for a chance encounter. As the network relation manager said:

> “those chats are only for those who participants in the chat, who are with you in a very particular moment. Now I would say, the real username, Jani, Pekka, or anybody who is working in this company, I can start to chat with these people….I would compare this chatting to a situation where you would be walking inside this premises, Pekka, Jukka, and Markku, by chance, running into each other on the corridor and start to talking” (Palosuo 2001)

7.2.2.2 Organizational psychology

The awareness counter is installed on the homepage of Siemens intranet and inserted into every sub-page dynamically generated by the Domino server. People can easily see how many online users there are on every page, find out who they are, and chat to them if they so wish. The daily users of Siemens intranet numbers more than one thousand and the average number of online users is between 50 to 60 in the daytime and 20 in the evening.

> “And then it slowly starts about 40 at 7 o’clock in the morning, and now it’s time we are reaching the peak, 11:24 in the morning, people are going to eat, want to know what’s for lunch, so that we easily get up to 150, or more [than] 160 [in the frontpage]...[the change of the number] is going on all the time...and then it goes down slowly… back to the nighttime. So it displays how the company is living. So it’s kind of additional awareness feature in a sense that it’s a kind of pulse to the company. Because, you can see, now everybody is online, and all the people, what they are going on…it has added-value itself by creating the feeling that you are not alone, there are 151 with me working in this company, I think, even thought, it’s just a counter but if you are working inside in the same company…it shows the activity in Siemens Finland…when the counter is low, people would ask where they are? And then there must be …events somewhere like the general managers might be speaking something in their rooms…it means something must have happened. And we have been using this for so many months. That people have learned...they know the curve [see FIGURE 30], they know there’s so many [live] people… we did not know this [before], but after using for several months, we have discovered…it’s amazing…and you can always imagine what comes next, suddenly if you know who are the other 151 [users], there are lots of possibilities to create energy between those 152 people. Yes, there are huge [possibilities]” (Palosuo 2001)

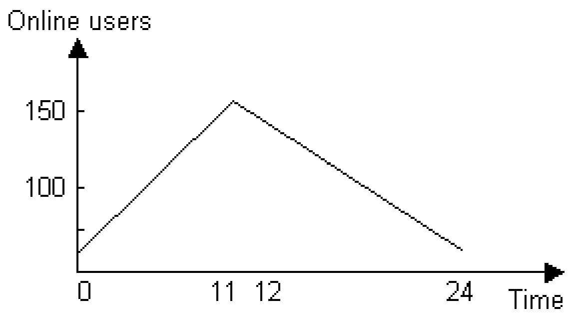

FIGURE 30 Distribution of online users

7.2.2.3 Privacy concerns

FIGURE 31 displays the curve showing the feelings of users towards violations of their privacy (sketched out by the interviewee).

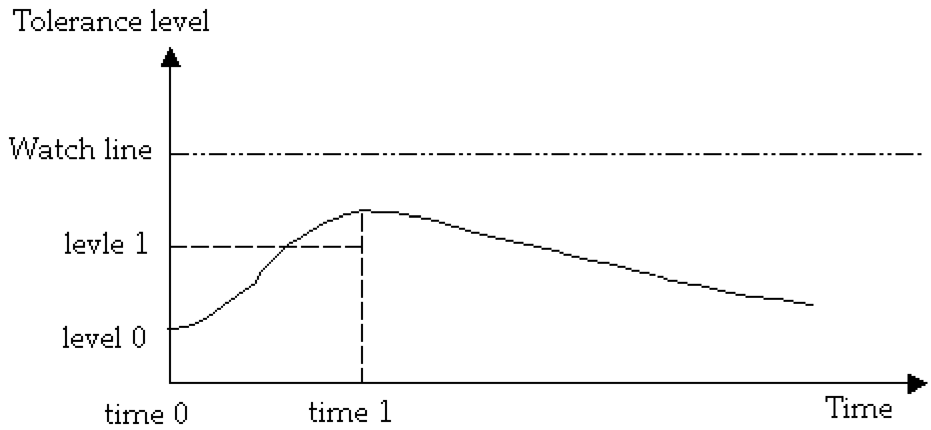

FIGURE 31 Privacy tolerance curve

In general, every piece of information about a user that is made available to others is a potential privacy violation. Fine-grained information about individuals' activities which are useful for cooperation and optimizing collective performance may also become a threatening resource in the hands of others. For example, in the case of Siemens Finland, we assume that the dotted line marks the maximum violation privacy of which users would be tolerant. The line commenced at certain level (level 1) as soon as the awareness engine was introduced. Gradually, the line climbed up to its top level (see FIGURE 31) with the other tools involved such as webcam, discussion boards, public polls, etc. Nevertheless a certain amount of space is left before people feel their privacy too much threatened. And one of the ways of keeping the curve flat is trust, the degree of trust among the users and between the users and the administrator. As the interview revealed:

> "if you are exposing people too much automatically, then they feel like there's a big brother watching on their every steps. This [has been] already a kind of feeling, and people are ready little bit easy about writing [in] the open channel. They know I can check their IPs, but only me, because I am the administrator of it. So far they trust [me]. And it's very sensitive. You can earn the trust and you can lose it quickly and never get it back again" (Palosuo 2001).

The same feeling was reported when the awareness system was deployed. At the beginning the counter played a sound (beep) as an aural indicator whenever someone came in and out. Theoretically, it is right to achieve ubiquitous awareness in this way but in practice it failed by annoying people too much- the gentle beep ended up becoming an unbearable noise because there were so many people coming and going. We ended up eliminating that aural function during our test in Siemens intranet. Eventually, with the running and using of such systems as people get used to the awareness information, the curve declines slowly. It is obvious, however, that the curve would climb up as new awareness features are added.

7.3 Requirement Analysis for CSCW

The study of various CSCW and groupware systems has led to the identification of a variety of requirement, which these systems have to meet. It needs to be stated here, that a CSCW system relates functional features to social aspects of teamwork. Each function has an impact on the work behavior and the efficiency of the whole group using the system. Furthermore, the capability of a CSCW system also influences the behavior of the individual group member. The key to the acceptance and success of CSCW systems, however, lies in the psychological social and cultural processes that take place within the group of collaborating people. However, I will discuss the general requirement of a CSCW system from functional perspectives only, as far as the present awareness system is concerned.

7.3.1 Requirements for Group Interaction

The requirements for CSCW systems are listed as requirement for group interaction. These are as follows:

- Coexistence: support for synchronous sharing of data and information about the presence of others;
- Communication: support for explicit communication through the exchange of messages or targeted interpersonal communication, and implicit communication through the propagation of changes to the workspace and the artifacts it contains ("double-level language");

- Coordination: support for the identification of goals, order of activities, assignment of activities to actors, allocation of resources, and synchronization of activities;
- Collaboration: support for data sharing and manipulation.

These requirements vary considerably in their importance to the design of an awareness system. Coexistence and communication are core requirements, because coexistence partially corresponds to informal awareness and because it is essential for social encounters (Huxor 1998) and so forth, and communication is a prerequisite for any kind of conversation or collaboration. Coordination and collaboration are of minor importance regarding the awareness system because collaborative information discovery and retrieval, information storage and administration, and even decision-making tend to be task and domain-specific, which are characteristics that can hardly be standardized and defined for such a general awareness system, especially a web-based one. As we know, the interactive process between users over the web is loosely cooperative in nature. It differs from traditional team or task-oriented cooperation where group tasks, goals, and purposes are usually well defined.

7.3.2 Requirements for Situation Awareness

The requirements for the provision of situation awareness in collaborative systems were categorized into requirements concerning the attributes and qualities of the information provided (Chapter 3 and 4) and into the mechanisms supplying it (Chapter 4 and 5). The general requirement for the provision of multifarious awareness information is divided into sub-requirements for human and system factors. The requirement for the provision of adequate awareness information requires as much flexibility in the mechanisms used for this purpose as possible. A desirable cooperative system can provide various aspects of awareness on different cognitive levels, and various mechanisms supporting awareness information in a flexible and adaptable way.

From a design standpoint, a clear understanding of situation awareness in a given environment rests on a clear needs analysis, that is, on identifying precisely what people need to perceive and understand. Therefore, systems tend to be highly context-specific, which is one of reasons why situation awareness is hard to describe in any valid way across arenas. Nonetheless, some elements can be, and should be, specifically determined for various classes of systems. Chapter 3 presented a methodology for accomplishing this and describes a general conceptual model of situation awareness.

Several other aspects of situation awareness should also be mentioned here. So far we have discussed various elements of situation awareness with respect to personal knowledge at a given point in time. Situation awareness is highly temporal in nature and is not therefore necessarily acquired instantaneously but is built up over time. Thus it takes into account what dynamics of the situation are acquirable only over time, and the need to analyze and project the state of the environment in the near future. The development of techniques to handle the collection and storage of awareness information over time presents a real challenge both technically and socially, especially in the case of mobile environments, as people cannot maintain a consistent note of the activities that have taken place and orient their work accordingly. Another aspect of the time issue needs also attention in the design of awareness-support systems. Tom Roden *et al.* (1997) presented the same research concerns under the heading "Temporal Issues":

> "The underlying assumption of most awareness models has been that time has little effect on awareness mechanisms. Information is transmitted instantaneously and delivery is reliable. In real distributed systems this is not the case and the issues of bandwidth and latency effect system behavior. In the case of large geographic distances it is physically impossible for many of the delays involved to be totally removed. Techniques are needed to manage the effects of these delays" (Tom Rodden *et al.* 1997, p. 2).

There are also some research models of awareness that cover requirements across all three levels of awareness in particular contexts, as for instance, Benford *et al.* (1996), who used a spatial model in their research into collaborative virtual environments (CVE). In the spatial model, awareness levels are defined per medium. The interaction between objects (which might represent people, information or other computer artifacts) in space is mediated through the relationships obtaining between three subspaces: aura, focus, and nimbus, which in turn represent the spatial extent of an object's locale, attention and presence. And the shape and size of each of the aura, focus and nimbus subspaces might be different.

7.3.3 Requirements Fulfilled

The awareness system provides continual cues regarding the coexistence of users on the same web page or on different but relevant pages. Users can have conversations with others viewing the same page or site at the same time. For long-term conversations, which are assumed to be independent of the web page currently displayed, users can integrate any auxiliary communication tools such as Netmeeting. Users in the same community can browse the page map, which display all the online users on different pages, or even different sites. Since users can also decide if they want to be interrupted at a particular moment, modes of interaction are rather unobtrusive. Shared artifacts like a group calendar, shared folders in other groupware are currently not supported directly, simply because the present study is not specifically aiming at building an entire web-based CSCW system. The system, therefore, provides a backend interface that can easily extend its capability by creating links to other kinds of groupware. Communication occurring in the system is mostly informal and spontaneous, through the external backend connection to other groupware, more formal conversations and coordination activities are expected to take place there. A conclusive review is given according to the requirements of CSCW and SA.

- Coexistence: Active support of coexistence—that is, the provision of synchronous awareness information is the primary goal of the awareness system. The page-based workspace (each web page is seen as a meeting and workplace) applied particularly stimulates social encounters and spontaneous communication.
- Communication: The awareness system supports the exchange of messages, that is, explicit communication, and propagates changes of personal states, that is, implicit communication.
- Collaboration and Coordination: The awareness system particularly aims at supporting collaboration. Features to be designed for collaboration support include the synchronization of browsers ("page-pushing"), a page-based annotation tool, a user search function, and so forth. These are the features most expected to be further explored and developed.
- SA theories: Chapter 3 discussed two levels of SA model: the cognitive level (perception, comprehension, and projection) and the system level (abstraction, temporality, aggregation, domination, and personalization). Chapter 4 added more product-level elements (user interaction, user attention, information, transmission, persistence, authorization, and operating platform) into the frame model, which formed a complete reference framework for SA.
- Concrete implementation: Chapter 5 analyzed the state-of-the-art technologies that SA systems to be enabled into the web. These designs can be used independently according to specific user awareness requirements. As a research outcome, Chapter 6 (Chapter 4 in part) described the concrete web implementation of a SA system that has elaborated mechanisms for the provision of awareness information about the presence, activities, and availability of others situated in the same place (or peripheral place) at the same time. The page view (see Chapter 6), for example, provides a list of all users visiting the same web page/site at the same time (including users' status and related information like the URL they are on and the idle time since the user in question came); the site map provides a list of all populated pages grouped as different communities (including titles of all populated pages and the number of respective visitors). Users can specify their availability through their settings. Therefore, users can assume that other users who are on the list are receptive to conversation.

7.4 Summary

"Collaboration in a groupware workspace is often awkward, stilted, and frustrating compared to face-to-face settings" (Gutwin and Greenberg, 1998b p. 511). The adaptability and resourcefulness of individual groups makes groupware in general difficult to evaluate. Nevertheless, I agree with Gutwin and Greenberg that “support for awareness will make substantial differences to usability” (Gutwin and Greenberg, 1998b p. 511), because of the special nature of collaborative interaction under the same context on the web.

In this chapter the present study was evaluated according to the result of a usability and case study. The primary goal of the evaluation was to examine the research hypothesis: that is, to test whether support of awareness enriches opportunities for online communication. The usability study was conducted to provide a large body of data and allow exploration of several questions. Quantitative analysis was done because of the nature of the application and the massive use of the awareness system. Furthermore, a qualitative study was carried out in a real work situation using system developed here. These two studies evaluated the practical part of the present research and provided a list of findings with suggestions for future developments.

As the study was particularly aimed at awareness support, full support of other CSCW requirements of CSCW was deemed unnecessary and therefore not implemented, for instance, the support of continual, formal and informal, articulation about actors, responsibilities, activities, conceptual structures, and resources as well as corresponding adaptation of the system; or information sharing, such as support for the intelligent sharing of information, taking into account transparency and information about the creators of information and other contingencies.

8 CONCLUSIONS

In this dissertation we have studied the theory of awareness and introduced a commercial product named the People Awareness Engine, which combines capability stemming from traditional CSCW and groupware applications with features suited to the web platform. This engine offers web users several modes of interaction: they can either navigate the web pages in a single-user mode, or they can interact with each other synchronously in real-time communication or navigate together through the system.

In this chapter, I will briefly specify what has been set out in the preceding chapters, mainly recapitulating the objectives that were defined for this dissertation in Chapter one, summarize the contributions made in the course of the dissertation, and suggest some ideas for future work with the aim of furthering awareness research.

8.1 Objectives of the Work

Cooperation in a work community requires that members of the group maintain awareness of one another on different cognitive levels. This type of awareness can be general or specific to concrete tasks and different requirements. Systems or artifacts employed in a system require some flexible mechanisms to provide such awareness information. The relations of cooperation on the web are special. They are looser and less task-oriented than those in the physical workspaces or traditional close-coupled groupware applications. Therefore, the specific awareness requirements and characteristics of the web concern the sets of things that need to be perceived and comprehended.

My research hypothesis is that a web system supporting and maintaining situation awareness between users can gain extra value to current existed web applications for two general purposes: chance encounter and informal communication. Situation awareness comes naturally in a face-to-face situation, but it is far more difficult to maintain effectively and efficiently in a distributed system, especially in asynchronous systems. In a web-based system, people may only see a fraction of the whole space (site), and worse – even may not “see” other people. In addition, not only does supporting awareness help simulate a real-life situation by providing similar visual and aural cues, but it can also provide extra capabilities that are hard to attain in the real physical workplace. We can control the awareness provision in different granularity levels.

8.1.1 Situation Awareness on the Web

The major issue addressed by web-based cooperation is the maintenance of situation awareness between remote partners when changes taking place in one location affect the activities in another.

Two kinds of situation awareness, user and workspace awareness, were described. User awareness of the web community is the general sense of who is around, where they are, and whether they are available, the sorts of things that people need to know when they are working together in the same “place” (page or site). Normally user awareness is generated subconsciously when people are browsing the web page, i.e. the workspace. The benefits of providing user awareness can range from a better success rate in reaching people on the web to finding an important connection between another person’s work and your own, that is to say, linking workspace awareness.

Workspace awareness can be understood as the knowledge of a dynamic environment. It is maintained through the perceptual information gathered from the environment, and it is conjoint to the group activity. The workspace is a specific setting which means a size-constrained environment where situation awareness can be applied. The definition of a workspace in the web environment is somewhat unclear because of its dynamic, open and unstructured features. Simply stated, a web workspace refers to any work that takes place on specific web pages via HTML forms or other state-of-the-art technologies. Therefore maintaining workspace awareness is largely a system-specific question and unlikely to show a standard or general design. This is, therefore, a need to apply the theory of workspace awareness in the design of awareness mechanisms for web-based collaborative systems.

In order to create mechanisms to support situation awareness, it is necessary to identify the different attributes of awareness information required, that is, identify what the group members need to perceive and understand. Although awareness information is normally specific to concrete systems and contexts, the conceptualization on awareness attributes can be useful, especially where there are determined and generalized from various real-life systems.

8.1.2 Research Questions

In Chapter 1, I raised several questions concerning the topic of awareness research. Same questions also have been studied by Markus Sohlenkamp in his dissertation “Supporting Group Awareness in Multi-User Environments through Perceptualization” (Sohlenkamp, 1999). Awareness support on the web is almost a completely different problem comparing to traditional awareness mechanisms for grouware applications. The support involves a wide range of aspects that have to be taken into account. In the following, I will re-examine these questions from other aspects and discuss the contributions that have made to each of them.

- Why is awareness important in multi-user environments, especially on the WWW?

Sohlenkamp has concluded that the most important form in multi-user environments is group cooperation: a system supporting the cooperation of users (Sohlenkamp, 1999). A multi-user environment is any computer system where some forms of interaction between users are intended. This definition covers other systems, like the web, not primarily intended to support group work or even grouping. One of fundamental requirements for multi-user environments is to identify others’ location and availability for communication, which belongs to the observation level of situation awareness (the Level 1 in Chapter 3). This capability makes it possible for people to engage in spontaneous communication, for example, like the concept of informal conversation, which has been shown to be highly important for cooperative work (Sohlenkamp, 1999).

We can see that the awareness research is becoming increasingly important alone with the development of the web itself. The first reason is that the maturity of Internet technologies has successfully guaranteed the technical requirements for awareness tools. The emergence of information appliances is making the web even more appealing to CSCW designers. The second reason is that the web itself is becoming an activity space, which people should be made more "aware" of. For instance, information consumers should be able to "see" and meet each other when they visit related places on the web. Also, information publishers should be able get a better idea of what is happening on their sites, in more naturally continuous and effortless ways.

- What are the key factors in the design of an awareness service?

“Multi-user environments are social-technical systems. The design of an awareness service therefore involves not only technical problems, but also social and organizational questions” (Sohlenkamp, 1999). Awareness support involves a flow of information from the originator of an action to the receiver. A conceptual framework was introduced in terms of human and technical factors (Chapter 3 and 4). By using the framework, different design elements can be taken into account when processing the flow of awareness information within multi-user environments.

- How can the systems support awareness on the WWW?

Unfortunately, the web is not the general solution to all groupware problems. Web applications are mainly based on HTML, which was intended to be a page layout language. Moreover, the web protocol is based on a request-and-answer fashion: clients send requests to a web server and receive information in response. There is no standard way for servers to automatically update the information that is displayed by clients. However, this is precisely what awareness support requires: presentation updates as the result of others' actions.

Three technical solutions were analyzed in terms of awareness support mechanisms: server, client and third-party (Chapter 5). As a basis for supporting situation awareness, user-tracking techniques were also studied and compared in relation to these three aspects of implementation (Chapter 5 and 6). These techniques can be used independently according to specific awareness requirements.

8.2 Summary of Contributions

> "Perhaps the most significant challenge faced by future developers of awareness mechanisms is to decide what users should be made aware of. Selecting which activities to make public and how these can be presented to users represents a significant design challenge, and at present there are only few existing design guidelines…suggests the need to allow users to make inferences from minimal sets of information. However, what that information is and how to judge what constitutes a minimum set remains an open question for CSCW researchers" (Rodden *et al.*, 1997 p. 2)

The overall aim of the research reported in this dissertation is to develop a model of the socio-technical dynamics of the web in supporting situation awareness and user communication, and to formulate methodologies and techniques for evaluating the model we propose. This dissertation emphasizes two issues: theoretical grounding and practical implementation, and has sought to make an important contribution to both of them.

8.2.1 The Model of Situation Awareness

Situation awareness has long been recognized as a phenomenon that deals with the degree of accuracy with which observers' perceptions of their current environment mirror reality. In this dissertation, I studied the concepts and constitutive elements of situation awareness as states of knowledge about dynamic environments. Situation awareness includes the perception of relevant elements, comprehension of the meaning of these elements in combination with and in relation to operator goals, and a projection of future states of the environment based on this understanding. Using this knowledge, individuals with good situation awareness will have a greater likelihood of making appropriate decisions and performing well in dynamic systems.

The vertical reference model of situation awareness presented (see FIGURE 32) in this dissertation addressed the elements that are critical to CSCW in both human (personal) and technical terms.

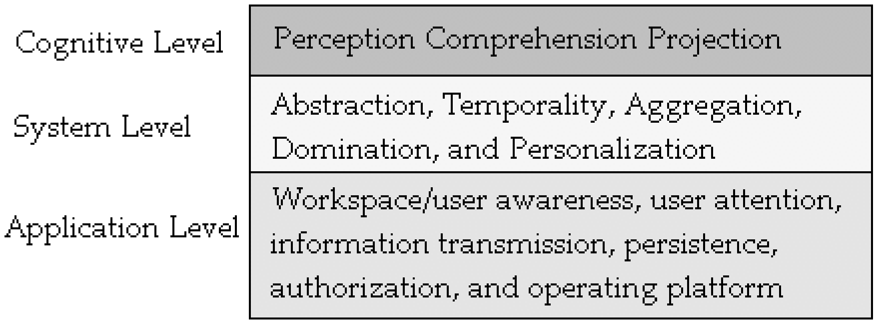

FIGURE 32 Vertical reference model of situation awareness

It should be made clear here that the cognitive theory and the models of the human mind, e.g. cognitive psychology, used in this dissertation are very simple. These models were inspired by my research into cooperative systems and how they process or access information. Of course there are other psychological approaches, such as psychobiological or social-psychological approach to human awareness problems. These theories may give a more complete understanding of how the human mind really functions. But theoretical study aside, since the second purpose of my study is to practical, and I therefore focus more on technical implementations, it is not surprising that these models offers "computer-related" explanations on how to adapt information processing tasks to human awareness. It is, of course, not wrong to use other psychological approaches to conduct research in the field of computer science; as it may well be an advantage, in other multidisciplinary approaches. By using other theories concerning information processing in the human mind, somewhat different conclusions may have been drawn. We believe that this is just a first step. We feel we have made encouraging progress and obtained some gratifying results. Much work remains to be done and the final goal is still a long way off.

8.2.2 The Roles of Awareness and Support on the WWW

Knowledge, or awareness information, plays a role in systems whenever a cooperative action is performed on the shared artifact. Presentation of this information to other participants at the user interface allows them to become aware of that action. Meanwhile, presentation of this information in itself keeps track of and confirms the potential awareness status of the task as well, in the same way as self-conscious mechanisms. Simply say, situation awareness acts as a notification service (Ramduny *et al.* 1998) within cooperative systems.

Different implementations of situation awareness address different cooperative work support mechanisms in order to take into account technical considerations and the nature of the collaborative work being done. In general the web lacks basic features to support human communication and consequently group working because of its origin- as a delivery vehicle for content publishing. In order to determine the appropriate form of models to support situation awareness on the web environment, an analysis of the technical possibilities in the web environment was carried out (Chapter 5).

Three different but internally related technical implementations were analyzed in terms of their capability to provide awareness support: clients, server techniques, and third-party applications. Server techniques guarantee the best consistency but have least flexibility and functionality to end-users. Client techniques are in the middle. Third party applications, on the contrary, can provide the best flexibility and functionality but the least end-user consistency. The weakness of server techniques is lack of flexibility and need for server-side installations. The weakness of third-party applications is lack of a communication channel linking the other two awareness implementations. Moreover, user awareness information provided by third-party applications is partial and incomplete because of the presupposition that mutual awareness is obtainable when and only when both users have the same third-party application installed.

8.2.3 Concrete Realization

On the practical side, the concrete implementation of a People Awareness Engine (awareness engine) supporting situation awareness on the web was discussed. In additional to previous situation awareness theory, a general application-level model was used (see Chapter 4) as a guide to the implementation of the specific web awareness engine (see Chapter 6). The results are not only of academic significance, but have high practical relevance as well. The concepts addressed in this dissertation can easily be transferred to and implemented in other electronic and mobile media applications.

8.3 Suggestion for Future Studies

The work presented in this dissertation raises at least as many new questions as it answers. Among them are open issues like:

8.3.1 Individual and Team Situation Awareness

So far few efforts to explain either the processes or the state of team situation awareness have been done in this study. It is possible to talk about situation awareness in terms of teams as well as individuals. In many situations several individuals may work together as a team to make decisions and carry out actions. In this case one can conceive of overall team situation awareness, whereby each member has a specific set of awareness elements about which he/she is concerned, as determined by each member's responsibilities within the team.

Situation awareness for a team can be represented as shown in FIGURE 33. Some overlap between each team member's awareness requirements can be conceived as the subset of information that constitutes much of team coordination. "That coordination may occur as a verbal exchange, as a duplication of displayed information, or by some other means" (Endsley and Jones, 1997, p. 41). As such, the degree of team members' awareness of shared elements (as a state of knowledge) may server as an index of the quality of team coordination (Endsley, 1995b).

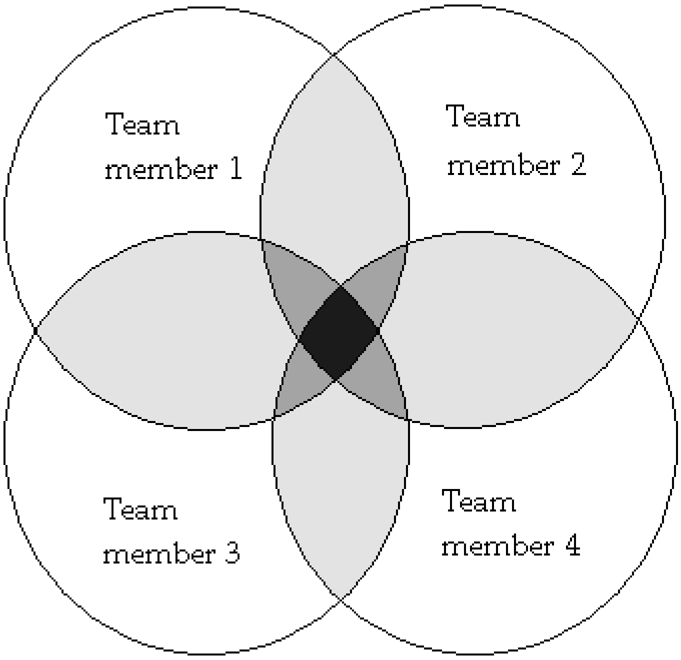

FIGURE 33 Team situation awareness (horizontal view)

8.3.2 New Awareness Reference Model and its Implementation

Overall team awareness can be conceived as the degree to which every team member possesses the awareness required for his/her responsibilities. How the transmission of that information occurs, the process of achieving situation awareness, will vary depending on how special systems are. It may be done via direct communication among team members, especially for higher levels of situation awareness that may not be directly presented on displays, or through a shared mental model.

We could identify awareness for groups as awareness of the group's collective long-term memory and awareness among and of each other by using the horizontal model above (see FIGURE 33). The model identifies three forms of awareness with respect to a group's long-term memory: personal awareness (white area, close, detailed, and deep awareness); peripheral awareness (yellow and green areas, less detailed, but still substantial); and global awareness (blue core area, the much thinner but usually most important).

While the general design features are appropriate to the development of most interactive systems, there are special considerations for the design of the team awareness service. Peripheral awareness, for example, can be developed through informal interactions, such as conversations, but it can also be developed through more formal mechanisms, such as institutionalized review processes (Chen and Gaines, 1997).

8.3.3 Integration of New Devices/Media

Recent research starts to emphasize the need to consider people's mobility when designing collaborative systems, especially with mobile devices such as phones and PDAs.

> "Consequently, all the tools that help manage communication, coordination, and awareness on the computer desktop are ineffective whenever the user is mobile. The proliferation of wireless devices that have some connection to a computer network (e.g., cell phones, wireless handhelds, two-way pagers) presents the opportunity of extending the benefits of awareness information to mobile users" (Tang *et al.*, 2001, p. 221)

One basic design objective for such a tool supporting mobile collaboration would be able to provide awareness cues to help people find opportune times to initiate contact in favor of the more naturally process of starting, maintaining, and ending communication (Tang *et al.*, 2001, p. 221). FIGURE 34 illustrates an ongoing study that creates a communication channel between web users and mobile users. The screen snap demonstrates that a live web-to-phone chat invitation based on the awareness system addressed in this dissertation has been just made.

In addition to using traditional desktop-based artifacts to represent awareness information, a number of researchers have recently started to put their efforts into how physical ambient environments can be employed for the representation of information like awareness, or even towards ubiquitous support of cooperative work (Gross 2000).

> "Studies of awareness support systems, for example, report problems with desktop-based presentation of iconic indicators and video windows that compete with other applications for screen real estate and user attention, and that easily become obstructed by other application windows. An interesting alternative is to move awareness information off the screen and into the ambient environment" (Schmidt and Gellersen, 2001, p. 747)

These ambient interfaces usually situate at the periphery of attention, but people can place them into a more important and visible locale by explicitly attending to them whenever necessary.

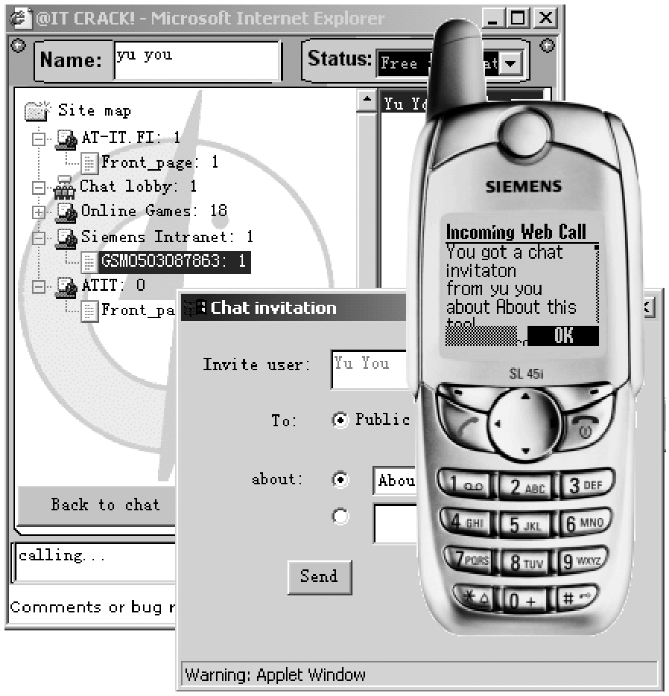

FIGURE 34 Communication between web users and mobile users

Recently, ambient displays have also been studied in the specific context of awareness support systems. For instance, Greenberg and Kuzuoka (2000) have designed a number of Digital but Physical Surrogates which are tangible representations indicating the activity and availability of remote people. Their peek-a-boo surrogate, for example, is a figurine that rotates to face away if the represented person becomes unavailable. The idea is, further, that manipulation of the surrogates can facilitate the move from mere awareness to actual communication. Another study of supporting visitor awareness based on the integration of ambient information displays with the web can be found in Schmidt and Gellersen (2001).

8.4 Future Exploration of Universal Awareness Service

I now attempt an overview of current and projected web technology to suggest a generic characterization of the features necessary to support the awareness of others that underpins several models of interaction.

The starting point will be that the basic web protocols are not suited or easily adapted to support awareness or real-time communication. Critical conversation is especially important in the face of the web’s exponential amounts of un- or semi-warranted information - e.g. many claims made on ‘medical’ pages. To support this we need to consider extended models that take into account flexible transmission and peer-to-peer communication (i.e. server-server, server-initiated server-client or client-client).

The design of an awareness service is closely linked to concrete server techniques and the requirements of the activities supported. A general awareness model (see FIGURE 35), or awareness information environment (Gross and Specht 2001), can be explored as a basis for web-based cooperative systems. Awareness support involves a flow of information from an action picker (a sensor) to a receiver via an awareness server. In addition, awareness information needs to be managed by a set of control components. The system helps to support the coordination of users, provides application-independent information to geographically dispersed members about members at both sites, such as their presence, availability, past and present activities, about shared artifacts, and about various other things that exist or happen at both sites.

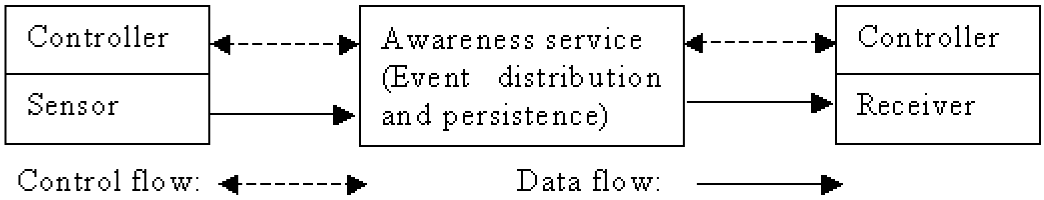

FIGURE 35 General awareness service model

In most cases, awareness information can be collected in two ways: on-line and off-line. On-line information mainly tracks user clicks, and page entry-leave actions (You 2000), for example the awareness engine discussed in this dissertation (see Chapter 4 and 6), and HumanClick. Users' focus and activity can be assumed from the position and movement of pointing devices, e.g. a mouse (a user-action is coupled with a system-event). Off-line information is often collected and used by traditional groupware (e.g. schedulers) and can be conveyed to web users via any awareness service, e.g. BSCW and variants (Trevor *et al.* 1997), Internet Foyer (Benford *et al.* 1996). Between sensor and receiver, the controller manages outgoing and incoming awareness information. Three types of controller need to be involved: a full-access controller to assure global consistency or adherence to organizational regulations; a sensor controller to assure user privacy when required; and a receiver controller to prevent disruption and information overload, and to enable customization.

Awareness information is stored and transmitted via a special server. Providing access to a history of past events is important in web systems because of "catch-up" needs. Even a historical report is useful to users who have been absent or disconnected for a while, especially mobile workers. Event databases can also provide additional context for past activities – such as where the activities took place.

The receiver represents or visualizes awareness information as specified by the controller and/or user. This controller attempts to ensure relevance and prevent information overload. Users can select, enable/disable awareness information that meets specific criteria. Besides user-defined criteria, system-defined rules may be imposed to guarantee organization-level objectives:

there may be things users are unable to filter out. These require explicit modeling of meta-events, and need to be designed carefully.

Technical possibilities are a two-edged sword. On the one hand, computer support offers possibilities going far beyond those available in cooperation without electronic support. In particular we note the enormous storage capabilities, the ease of information retrieval, and support for innovative presentation and visualization techniques.

On the other hand, computers are restricted in many ways. Input and output devices only support a small part of the human sensory system. Screen space—by far the most important output medium—is a very limited resource. This makes it difficult to convey the rich information available in real-life, same-place cooperation. Thus techniques to make better use of the available resources have to be developed to make the net more lifelike, or, as Hollan and Stornetta (1992) suggested, to bring the unique affordance of electronic media into everyday life. Our position is broadly neutral between 'lifelike' and 'enhancing', although we lean towards supporting a 'lifelike' model with media and methods that enhance rather than replicate ordinary life. Some kinds of interaction that need awareness of other people, and have been implemented, are considered below.

> "When Eric Pegureo-Winters visited Landsend.com early this summer, he struggled to find a shirt he had previously seen in a catalog. So he clicked the 'help' icon, and a sales rep took control of his browser and let him to a picture of the shirt. Then the rep used instant messaging to describe embroidery not visible on the screen." (Berner 2000)

Examples such as this rely on a predictable coupling of user action and system event — clicking a button for help — as done by HumanClick and LivePerson (Jackson 2000). Put like this, we see that the 'receiver' (helpdesk) is unaware of others until they initiate action. A different model is utilized by ICQ and the People Awareness Engine. In ICQ, people are aware whenever pre-identified others are online anywhere. In the People Awareness Engine, visitors have a heartbeat[11] that is heard by the server, and can be echoed to all other visitors to the same page(s), site, or community. In ICQ, awareness of known others wherever is supported. In the People Awareness Engine, awareness of all others locally is supported. In both cases, mutual awareness is provided by simple presence, and does not rely on a specific user action. Each of these scenarios can be mapped onto the Awareness service model, and each can be useful to some people some of the time. After awareness has been provided, the interactions supported by these examples are extremely simple — text chat.

However, more sophisticated conversational media (audio, video) will need to make similar choices between specific realizations of the Awareness model. Currently hearing (audio) and seeing (video) are not supported in these contexts because of the limits of the Java programming language or

[11] More accurately, the page they have downloaded has an applet that pulses.

inadequate technical devices (either they are not always available, the computers are not powerful enough, or some services have been restricted).

When continuous media (web-cameras, audio and video conferencing systems) do become available in combination with an underlying awareness service, empirical questions arise about how useful they will be. Is it really possible to check the freshness of tomatoes by video? Is text as powerful or better than audio in helpdesk work? To whom? Under what circumstances?

Another question arises about the location (one might say locomotion) of the awareness service. How about carrying virtual awareness of others around with us? The predictable coupling model (action to system event to receiver awareness) is already widespread in the cell phone. Would it be useful to implement other awareness models as provided by ICQ and the People Awareness Engine?

It is now just about possible to browse web pages through the mobile phone. But WAP is even more severely limited for awareness purposes. Terminals are difficult to use, as the number pad is a number pad, and not designed to input text in general, and certainly not at the speed necessary for live chat. The screen is too small to present serious page information, let alone background awareness service indicators with the page. Network connections are slow due to bandwidth and server capacity limitations. When the technology has developed enough, for instance with iMode or UMTS[12], the Web, and various awareness services, can be brought into the mobile world using the same underlying models.

Combining the web with domestic appliances is another much discussed area. There are machines that include a web interface, e.g. an Internet fridge by Electrolux (2000). These prototypes concentrate on technical issues of how a system should and could be implemented, but ignore many usability aspects. Obvious problems occur. When items are taken from the fridge (milk, tomatoes) how are they identified? Bar code readers are suggested, but would you use a bar code reader every time you access the fridge? How is the system synchronized when used locally, via the web personally, and via the web automatically? How are users identified, and intruders kept out? (For a wider discussion see Pekkola *et al.* (2000)). It seems unlikely that purely algorithmic mechanisms of interaction could resolve many of these issues. Most complex systems need to mesh automation with human coordination and discretion (Schmidt 1999). So again, it is likely that choices will need to be made about the appropriate underlying awareness service for cookers, fridges, washing machines, and so on. This of course extends the above interpretation of the awareness model to include machines and artifacts as well as people.

We supported the calls from many commentators to include human interaction in the web, rather than as extra that has to be sought outside the web. We suggested a generic model of awareness, and some specific interpretations: action-event couplings to call a receiver; general awareness of known others (e.g. ICQ) and local awareness of all others (e.g. People

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12 IMode (http://www.eurotechnology.co.jp/imode/), and UMTS (http://www.umts-forum.org)

Awareness Engine). We then considered extensions to the web into mobile and into domestic appliances, and suggested that an underlying awareness service will be needed there as much, or even more than in classic desktop web access.

We surmise that an interactive web is never going to replace reality, if reality is loosely equated to face-to-face (Hollan and Stornetta 1992), but it can, and already has added dimensions of depth and scope to human interaction that were simply not there before. We hope it does well, but we see this as just one realization of the awareness model among many — as a very small step in the direction of a web where mutual awareness is not only omnipresent and multi-media, but taken for granted. After all, it is no surprise that we can see and react to the people who share a room, airplane seat, or street with us.

YHTEENVETO (FINNISH SUMMARY)

Tietokonetuetun yhteistyön (CSCW) tutkimusta on harjoitettu jo kymmeniä vuosia ja ohjelmistoteollisuus on ottanut tutkimuksen tuottamia tuloksia käyttöönsä. Tästä huolimatta vakuuttavat virtuaalisen yhteistyön www –sovellukset ovat edelleenkin kehitteillä vaikka www onkin muotoutunut tuollaisen yhteistyön pääasialliseksi välineeksi. Tähän tilanteeseen on useita eritasoisia syitä teknisistä seikoista aina sosiaalisiin ja organisatorisiin ongelmiin saakka. Erityisesti on todettavissa että monet järjestelmät eivät lainkaan tue käyttäjien tietoisuutta toisistaan tai järjestelmän tarjoama tilannetietoisuus ei ole selkeästi esitetty. Kuitenkin käyttäjien tilannetietoisuutta pidetään CSCW –järjestelmien perustavaa laatua olevana tekijänä, sillä se mahdollistaa käyttäjien oman työn suunnittelun ja koordinoinnin samalla muita käyttäjiä ja heidän tekemisiään tarkkaillen. Tämän väitöskirjan aiheena onkin käyttäjien tilannetietoisuus käyttötilanteessa. Tässä väitöskirjassa väitetään, että muiden käyttäjien jättäminen huomioon ottamatta haittaa yksilön työskentelyä erityisesti www -pohjaisissa CSCW –järjestelmissä, joissa toisistaan erillään olevat käyttäjät käyttävät järjestelmää samanaikaisesti. Väitöskirja tutkii sopivan tilannetietoisuutta tukevan toiminnallisuuden toteuttamista tällaisissa järjestelmissä.

Väitöskirjassa raportoidun tutkimuksen yleisenä tavoitteena on kehittää tilannetietoisuutta ja käyttäjien kommunikointia tukeva, www –ympäristöön sopiva sosio-tekninen malli ja formuloida ehdotetun mallin arviointimetodologioita ja -tekniikoita. Tässä väitöskirjassa keskitytään kahteen seikkaan: tilannetietoisuuden teoreettisiin perusteisiin ja sen toteutukseen käytännössä. Verrattaessa tämän väitöskirjan tutkimusta perinteiseen tutkimukseen tilannetietoisuudesta ja sen tietokonetuesta, todetaan tässä työssä keskityttävän erityisesti inhimillisiin tekijöihin ja teknologioihin. Näinpä tämän tutkimuksen tavoitteet ovat: 1) tutkia tilannetietoisuuden ominaispiirteitä ja niiden esittämistä ja 2) tutkia niitä erilaisia järjestelmämekanismeja joilla tilannetietoisuuden eri vaatimukset voidaan suurelta osin tyydyttää.

Käytännön soveltamisen näkökulmasta työssä tarkastellaan tilannetietoisuuden tuen toteuttamista ohjelmistosovelluksen avulla. Yllä käsitellyn tilannetietoisuutta käsittelevän teorian pohjalta työssä tuotetaan yleinen sovellustason malli, jota voidaan käyttää ohjaamaan tiettyyn käyttötilanteeseen tarkoitetun tilannetietoisuutta tukevan ohjelmiston toteutusta. Täten tämän väitöskirjan tulokset eivät ole merkittäviä pelkästään akateemisesta näkökulmasta vaan tulokset ovat myös käytännön soveltamisen kannalta relevantteja. Vaikka työssä tarkastellaan vain yhtä sovellusta, ovat esitetyt käsitteet helposti siirrettävissä ja toteutettavissa myös muiden elektronisten ja liikkuvan tietojenkäsittelyn sovellusten yhteydessä. Tietenkin tämä tutkimus on vain yksi tilannetietoisuusmallin tuen toteutus monien muiden vastaavien mallien toteutusten joukossa ja näin ollen se on nähtävä yhtenä hyvin pienenä askeleena pyrittäessä www –sovelluksiin, joissa käyttäjien keskinäinen tilannetietoisuus ei ole ainoastaan kaikkialla ja kaikissa mediamuodoissa läsnä vaan on itsestään selvä osa järjestelmää.

概要 (CHINESE SUMMARY)

万维网(WWW) 已经成为一种能让人们把它作为一个基于共同利益的虚拟合作的交流平台的主要媒介。虽然近十年来计算机支持的合作工作(CSCW)是一个热门研究课题, 并且甚至在软件产业中, 这种概念已经得到采用, 可是令人信服的网上解决办法仍然欠缺发展。这是多种原因造成的，包括从社会，组织化问题到完全技术上的问题所造成的。尤其很多 CSCW 系统使人们很难, 甚至完全不能意识到彼此的存在。这篇论文的主题，情景意识 (situation awareness)，在 CSCW 系统里被看作是一个基本的和主要的组成要素，因为它允许人们容易地了解其他人的当前工作状况,从而可以协调和组织自己的工作。这篇论文辩论了那种忽视其他相关用户的技术设计在系统里是如何妨碍人们相互合作的，尤其在基於因特网上的 CSCW 系统. 这种系统设计虽然使得用户在网上可以同时与系统进行交互工作，但是和其他用户之间却是彼此相互隔离的。这篇论文也研究如何提供适当的解决方案来支持网上的情景意识。

这篇论文总的研究目的是设计一种基于万维网的社会技术动态性, 能够支持情景意识和用户交流的模型，并且提出为了评估这种模型需要的相应科技技术和研究方法学。论文着重从技术理论基础和技术实际实施两方面阐述问题。与其他传统的情景意识研究所不同的是，这篇论文从人性因素和信息技术因素两个角度研究情景意识。由此决定我的研究目标是：1) 情景意识和可能的主要相关属性及表现; 2) 能够最大程度满足不同情景意识需求的系统机制。

在实际应用方面，这篇论文讨论了一个系统在因特网上支持情景意识交流的具体的实现过程。再加上前有的情景意识理论研究，论文提出了一个通用的应用级水平的模型, 这个模型可以被提出并且对具体的因特网上情景意识系统的设计也有一定的参考价值。这篇论文的结果不仅具有理论上的意义，而且也有很高的实际应用性。这篇论文所讨论的那些技术理念能够容易地被转移, 并且实现在其它电子和移动媒体环境里。当然，这项研究成果仅仅是在众多情景意识模型研究里的一种实现 -所迈出的很小的一步, 这小小的一步将为我们带向未来一个无所不在的支持相互意识和多媒体的网络世界。

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Appendix I Acronym Glossary

CVE	Collaborative Virtual Environment
CSCW	Computer-Supported Cooperative Work
DSS	Decision Support Systems
EC	Electronic Commerce
IS	Information System
JFM	Java Media Framework
NS	Notification Server
PAW	People Awareness Engine
SA	Situation Awareness
WWW	World Wide Web

Appendix II Usability Study – Web Questionnaire

Q1: Do you like 'seeing' other on-line players?

- (●) Yes, why not
- ( ) No, I want to play alone
- ( ) Sorry, I have no idea

Q2: Do you like the live awareness counter (see below the screenshot) in our site? It shows the current on-line users in this page.

- (●) Yes (or just so-so)
- ( ) No, please remove it ASAP
- ( ) Ooh, I thought it's a normal hit counter
- ( ) Sorry, I have no idea

Q3: Would you like to communicate with other players on-line through this awareness tool (By clicking the counter)?

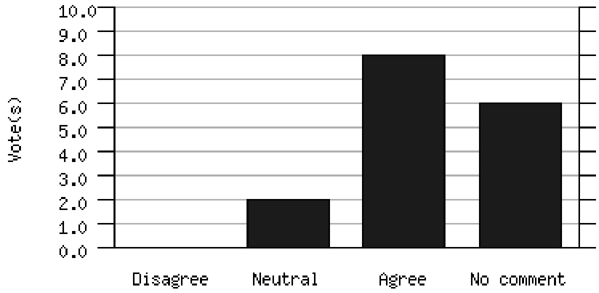
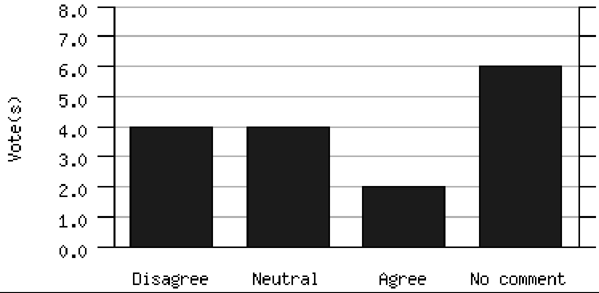
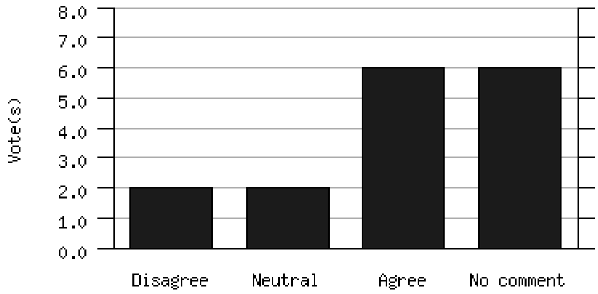
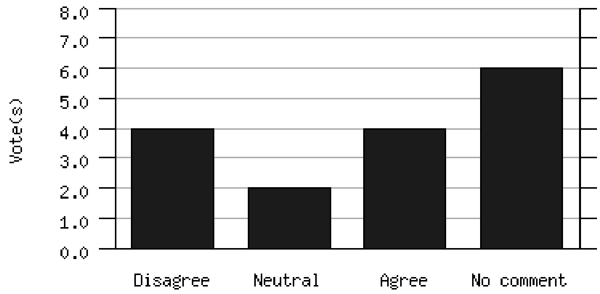
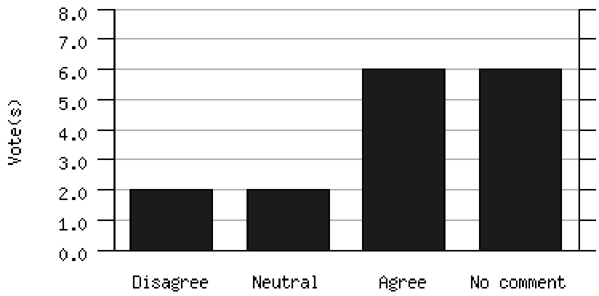
- (●) Yes (or just so-so)
- ( ) No, it's hard to use
- ( ) No, nobody is there
- ( ) Sorry, never tried

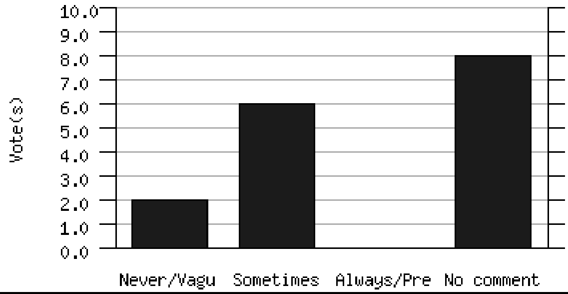
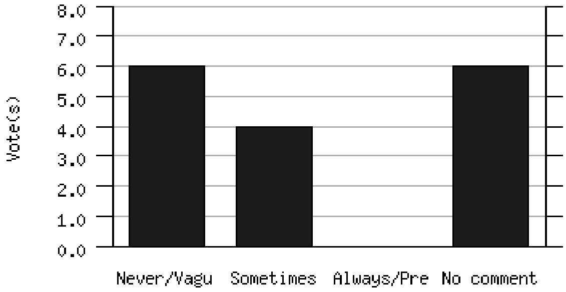
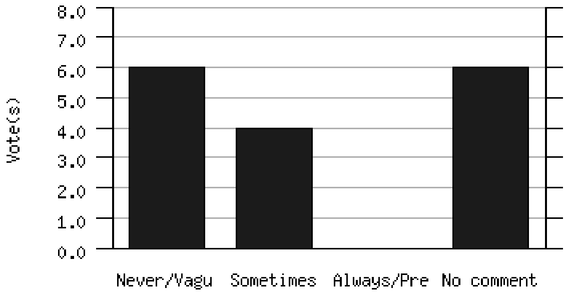
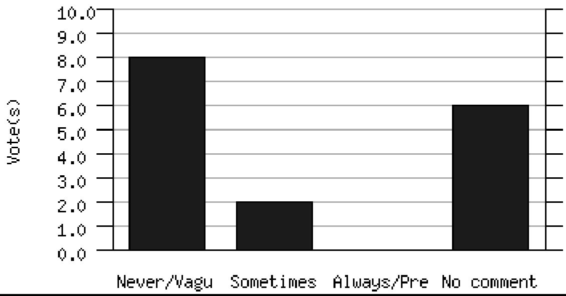
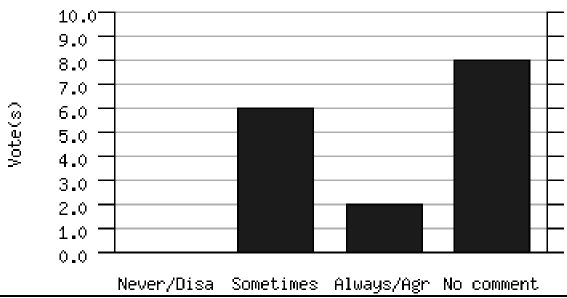
Q4: How often did you know where other players were in the Game site (by using the awareness tool)?

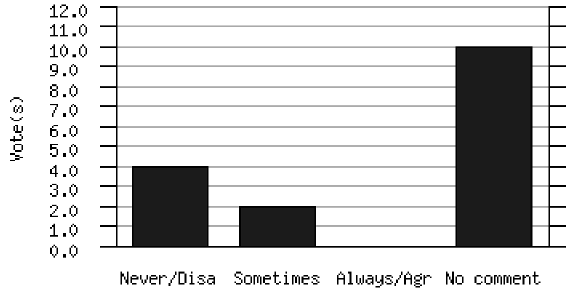
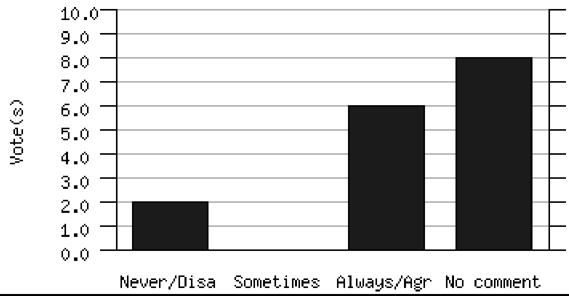
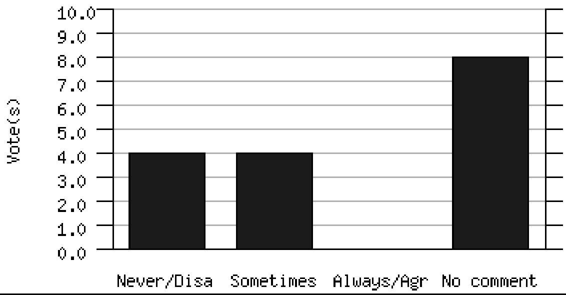
- ( ) Always
- (●) Sometimes
- ( ) Never

[:: SUBMIT ::]

Appendix III Case Study – Web Questionnaire and Results

Questions	Results
I. Observation	
1. Through this tool, you can obtain the information about how many online users.	
2. Through this tool, you can obtain the information about who they are.	
3. Through this tool, you can obtain the information about where other users are, i.e. in which web page.	
4. Through this tool, you can observe the activities of others to coordinate your work, or their contact situation / signal, i.e. the availability or willingness for communication.	
5. Through this tool, you can easily start a text conversation with others, if necessary.	
II. Comprehension	

6. Through this tool, How often were you aware of which web page your partners were?	
7. Through this tool, How often were you aware of the activity of your partners, based on their online status?	
8. Through this tool, How often were you aware of what your partners were doing (or their intention based on their web page location)?	
9. How precisely did you know what they were doing, or any changes updated?	
III. Usability Study	
10. How often did you click the live user counter to check the situation of opther online people?	

11. The counter distracted me from my work?	
12. The whole awareness tool is easy to understand?	
13. The awareness tool provided me useful awareness information about my colleagues?	
14. The awareness tool is a valuable part of the Intranet and needs further development.